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INTERLABORATORY STUDY 89-6

METALS, NUTRIENTS & PHENOLICS (4-AAP) IN REAGENT WATER

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INTERLABORATORY STUDY 89-6
METALS, NUTRIENTS & PHENOLICS (4-AAP)
IN REAGENT WATER

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1 SUMMARY AND CONCLUSIONS

This interlaboratory study was initiated, as part of an ongoing program of the Quality Management Office (QMO), Laboratory Services Branch (LSB) Ontario Ministry of the Environment (MOE), to evaluate the ability of environmental laboratories to measure the common trace metals, nutrients, and phenolics in reagent water.

Fifteen trace metals, two nutrients, and phenolics (for a total of eighteen tests) were included in this study. All participants were requested to use their analytical method which conformed to the MISA (Municipal and Industrial Strategy for Abatement) regulations. Thirty four laboratories participated in this study. Not all laboratories reported results for all the tests.

Three samples of each type namely metals, nutrients, and phenolics were prepared by the QMO and distributed to the participants in September 1989.

The results as they were received were entered to a LOTUS 123 spreadsheet. A hard-copy of the electronic spreadsheet was sent to all participants for verification. The performances of the participants were evaluated, for each parameter, using a graphical procedure developed by the QMO[2]. By a process of iterative elimination of suspect data, the repeatability (S_w) achievable for each parameter was determined. This S_w was used to determine the warning and control limits for each parameter.

Laboratories that produced results within the warning limits were appraised as producing results of acceptable performance. Such laboratories are considered to be capable of generating valid analytical data. These criteria are based on the performance of the most comparable participants. Total tests for a given category (metals, nutrients, or phenolics) is the sum of the number of participants for each test within that category.

For the trace metal category results of acceptable performance were produced in 72% of the total tests. 12 % exceeded the warning limits but were within the control limits. The majority that were flagged as biased exhibited slope related problems. Use of certified standards and appropriate calibration procedures by these laboratories may lead to more comparable analytical data.

In the nutrient category results of acceptable performance were produced in 59% of the total tests. 12 % exceeded warning limits but were within control limits. No single type of bias was dominant in the laboratories flagged as biased.

For the phenolics test only 30 % of the participants produced results of acceptable performance. Many laboratories exhibited intercept related problems. Appropriate blank corrections may lead to more satisfactory data. A few laboratories showed slope related problems. These laboratories had problems with their standards and/or the calibration procedure. Follow-up interlaboratory studies for this parameter will provide a continuing assessment and promote better performance.

The observed mean values of most comparable laboratories for all the tests were essentially equal to the target values. Thus it may be concluded that the comparable laboratories on average are accurate.

2 INTRODUCTION

Interlaboratory performance studies or round robins, are conducted for a variety of reasons. These include:
- to assess data comparability and monitor laboratory performance,
- to identify bias and precision or accuracy problems,
- to validate analytical methods,
- to determine 'true' value for certified reference materials, and
- to promote self-improvement.

The Quality Management Office (QMO), Laboratory Services Branch (LSB) of the Ontario Ministry of the Environment (MOE) has instituted an on-going program of round robins to assess and promote the performance of environmental laboratories providing analytical services for a variety of different programs.

Interlaboratory study 89-6 was designed to assess the analytical variability of a number of inorganic parameters and phenolics in reagent water. The parameter list was chosen from five different test groups listed in the MISA (Municipal and Industrial Strategy for Abatement General Regulation [1]. The participants were requested to use methods which conformed to the MISA analytical principles and protocols given in the General Regulation (Ontario regulation 359/88).

Invitations were sent to several laboratories known to the QMO at that time as doing MISA work. Thirty six laboratories agreed to participate. Not all of the participants reported results for all the tests in this study. Two laboratories withdrew from the study after receiving the samples. A list of participants is included in appendix 1.

Three samples of each type namely metals, nutrients, and phenolics were prepared by the QMO and distributed to the participants.

3 TECHNICAL OUTLINE

3.1 SAMPLE PREPARATION

3.1.1 REAGENTS

1. Concentrated Nitric Acid, Aristar

2. Concentrated Sulfuric Acid , Fisher ACS grade

3. Deionized distilled water

4. MOE Multi-Element Standard (see section 3.1.2 for specification)

5. MOE Boron Standard (see section 3.1.2 for specification)

6. MOE Nutrient Standard (see section 3.1.2 for specification)

7. MOE Phenolics Standard (see section 3.1.2 for specification)

3.1.2 STANDARDS FOR SPIKING

All standards were prepared by the MOE Quality Management Office. The standard solutions were dispensed into ampoules, sealed and stored at room temperature. The concentrations of prepared ampoules were verified by a MOE laboratory by analysing simultaneously six samples prepared from randomly selected ampoules along with six samples prepared from appropriate EPA (Environmental Protection Agency, U.S.A.) Certified standards. In all cases, with the exception of iron which was about 4% lower than the design value, the 99% confidence limits of the results included the design values. Hence the design values were used to represent the target concentration of test parameters in all inter-laboratory study samples.

The mean result of the selected laboratories were all found to be within 4% of the target value for all parameters including iron. This finding justifies the use of designed values in estimating the target values.

<u>Boron Standard.</u>
Lot#: INA011 Ampoule size 25ml
Date of Validation: June 30, 1988

Designed (mg/L)	Found (mg/L)	
	Mean	99% Confidence intervals
100	95.21	±5.7

Multi-Element Standard.
Lot#: TMCOMB3 Ampoule size 50ml
Date of Validation: June 30, 1989

Element	Designed (mg/L)	Found (mg/L)	
		Mean	99% Confidence intervals
Al	100	98.69	±2.29
Be	20	19.94	±0.34
Cd	20	19.71	±0.34
Co	20	19.84	±0.24
Cr	20	19.94	±0.25
Cu	15	15.04	±0.25
Fe	200	191.5	±2.45
Pb	100	100.4	±1.83
Mn	15	14.93	±0.17
Ni	20	20.40	±0.53
V	20	19.96	±0.30
Zn	25	25.05	±0.30
As	20	20.01	±0.14
Se	20	19.62	±1.17

Nutrient Standard.
Lot#: NUT0013 Ampoule size 50ml
Date of Validation: April 28, 1988

	Designed (mg/L)	Found (mg/L)	
		Mean	99% confidence interval
TKN	480	489.3	±13.7
TP	27	27.7	±6.5

Phenolics Standard.
Lot#: PHEN01 Ampoule size 20ml
Date of Validation: Sept. 20, 1989

	Designed (mg/L)	Found (mg/L)	
		Mean	99% Confidence intervals
	10	9.97	±0.09

3.1.3 PROCEDURE

10 L of each type of sample was prepared. Deionized distilled water (DDW) was used as matrix for all samples. In every case the appropriate intermediate solution (2L) was prepared by quantitatively transferring designated amounts of standard solutions and acid into a 2L volumetric flask containing approximately 1500 mL of DDW (see table 3.1) and then made up to volume with DDW. The entire intermediate solution was transferred into a clean 12 L Nalgene bottle and to this bottle four more portions of 2 L each of DDW was quantitatively added to make up a total volume of 10 L. The contents of the Nalgene bottle was thoroughly mixed using a magnetic stirrer. With the aid of a peristaltic pump about 250 mL of this bulk solution was dispensed into appropriately labelled sample containers(see table 3.1)

3.2 DISTRIBUTION

Prior to sample preparation, the participating laboratories received a letter of notification. Laboratories confirmed their willingness to participate in this study by letter or telephone. Each participant was assigned a laboratory identification code. A list of participating laboratories and examples of correspondence with participants are included in appendix 1.

A total of nine samples, three for metal analysis, three for total nutrient analysis and three for phenolics analysis were packaged in cardboard boxes and were shipped to most participants via Purolator courier on September 26, 1989. A few samples were hand delivered. For those participants that agreed to analyze only some of the parameters, the relevant samples were dispatched. No sample losses in transit were reported. Included with the samples were result reporting forms for each type of sample. The laboratories were requested to identify the digestion procedures and the instrumental methodology used in their analysis.

3.3 DATA HANDLING

The majority of the laboratories utilized the result reporting forms to submit their findings to the QMO. All data were manually entered by laboratory code into an electronic spreadsheet. Blank spaces were entered when a laboratory did not report results for a specific parameter that was present in the spiking material. A "0" was entered when a laboratory reported "Not Detected". When a laboratory reported a result with a remark code "less than" or "<" preceding a number, the results were entered in one of two ways. If the number was less than the amount spiked, then a "0" was entered. Otherwise the actual number was entered. In any event these results, although used to evaluate the respective individual laboratory performance, were excluded in the estimation of various statistics.

Tables of results were sent to all participants for verification on December 4, 1989. Laboratory 3016 identified a calculation error of a factor of 5 on their part for Aluminum results. Laboratory 3029 identified a transcriptional error on their part for one of their Manganese results. Upon verification of the raw data, the changes were accepted and appropriate corrections to the spreadsheet were made. While this procedure might be subject to misuse by laboratories, it ensures better estimates of the statistics used in the performance evaluation.

TABLE 3.1

Spiking chart for sample preparation

SAMPLE	SPIKING STANDARD	ACID	SAMPLE CONTAINER
MET 1	NONE	25 mL HNO_3	PET 500 bottles
MET 2	50 mL of Multi-Element Standard TMCOMB3 and 50 mL of Boron Standard INA011	25 mL HNO_3	PET 500 bottles
MET 3	150 mL of Multi-Element Standard TMCOMB3 and 150 mL of Boron Standard INA011	25 mL HNO_3	PET 500 bottles
NUT 1	NONE	6 mL H_2SO_4	PET 500 bottles*
NUT 2	50 mL of Nutrient Standard NUT0013	6 mL H_2SO_4	PET 500 bottles*
NUT 3	200 mL of Nutrient Standard NUT0013	6 mL H_2SO_4	PET 500 bottles*
PHN 1	NONE	1 mL H_2SO_4	250 mL glass bottles containing 2 mL of 50% H_2SO_4**
PHN 2	10 mL of Phenolics Standard PHEN01	1 mL H_2SO_4	250 mL glass bottles containing 2 mL of 50% H_2SO_4**
PHN 3	40 mL of Phenolics Standard PHEN01	1 mL H_2SO_4	250 mL glass bottles containing 2 mL of 50% H_2SO_4**

* pH of samples were verified and found to be approximately 1.7

** pH of samples were verified and found to be between 1.5 - 2

4 EVALUATION METHODOLOGY:

Evaluation of the laboratory performance was evaluated out by the procedure described in the paper "Classification of Systematic Errors using Two Samples at Different Concentrations" by D.E.King and S.S.Selliah, 1991[2].

The samples MET 1, NUT 1 and PHN 1 had no analyte spike and as expected most laboratories reported "Not Detected" for most of the parameters. The results of these samples were not used in the study evaluation. Reporting a significant amount of particular analyte for these sample by any laboratory will indicate a blank problem experienced by this laboratory in the measurement of this analyte. If the uncorrected data indicates a blank-type bias based on the Youden plot, one can evaluate the effectiveness of the reported value of the 'blank' sample for correcting bias.

A step-wise summary of the evaluation procedure for this study is given below.

Summary of The Two-Sample Performance Evaluation Procedure.

a) Two samples at different concentrations are split among a number of laboratories and then analyzed using their current methodology conforming to the MISA analytical principles and protocols.

b) Tabulate data on LOTUS 123 spreadsheet.
Calculate median, mean and standard deviation.
Tabulate data and return to lab analyst for verification.
Correct database if transcriptional errors were reported.

c) High Sample data evaluation:
i) -reject data if more than 10% different from median,
ii) -calculate median, mean (H), Standard deviation (S_H), and Standard error (SE_H)
iii) -reinclude data if within 3 times S_H,
iv) -reiterate ii), and iii), until no further data is included.

d) Low Sample data evaluation:
i) -use S_H times 3 to exclude possible outliers,
ii) -calculate median, mean (L), standard deviation (S_L), and Standard error (SE_L),
iii)-use S_L times 3 to identify outliers.

e) Paired Sample Performance Criteria:
- i) -use only data from labs that passed both c) and d) above,
- ii) -examine the ratio of S_H/S_L
  if <2 use data as reported in concentration units,
  otherwise convert to % recovery based on mean value (H,L),
- iii) -determine average repeatability S_w based on paired data,
- iv) -set warning limit for repeatability = 2 times S_w,
- vi) -set control limit for repeatability = 3 times S_w,
- v) -set warning limit for possible bias = 3 times S_w,
- vii) -set control limit for possible bias = 4.5 times S_w.

f) Laboratory Performance Evaluation
- i) -prepare paired sample scatter diagrams of all data,
- ii) -use LOTUS 123 program to code performance:
  -in upper left or lower right quadrant (erratic)
  -in lower left and upper right quadrant (biased low or high)
  -on horizontal or vertical axis (out of control)
  -on diagonal line through origin (slope or standard problems)
  -on diagonal not through origin (intercept or blank problems)
- iii) -prepare summary table of performance assessment.

5 RESULTS AND DISCUSSION

5.1 PERFORMANCE EVALUATION BY PARAMETER

Each parameter in this study was treated by the evaluation protocol described in section 4. In all cases the medians of the selected laboratories (i.e. those laboratories that passed both steps c and d described in the step-wise summary of the evaluation procedure, section 4) were found to be within the range of target ± three times the appropriate standard error (section 4) and hence the target was used in all evaluations. The results of each individual parameter are presented in Figures 5.1 to 5.18 and in Tables 5.5.1 to 5.5.18 (appendix 3).

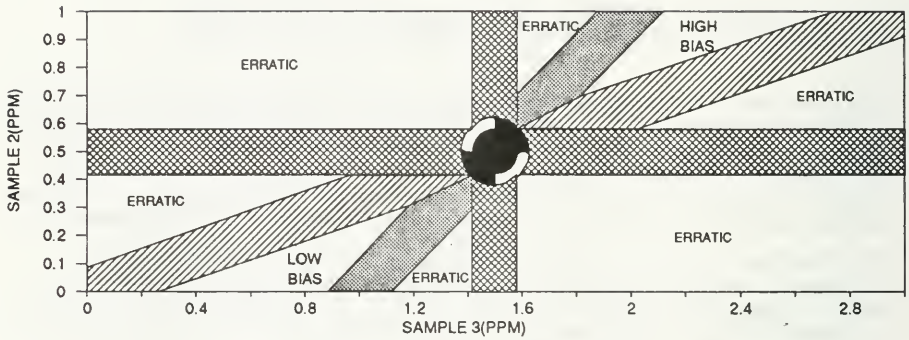
"Warning limits" have been used as the basis for flagging laboratories that did not demonstrate acceptable repeatability or reproducibility. The warning limits and control limits for repeatability are set at $2S_w$ and $3S_w$ respectively. Note that the factors used are somewhat arbitrary but they represent approximately 95% and 99 % confidence intervals.

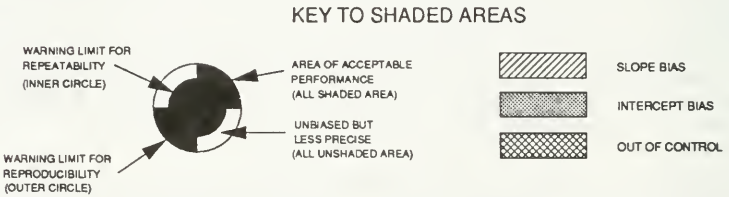
Additional tolerance is required for the effect of variability in preparing and using standards on a day to day or among laboratory basis. The factor 1.5 for the ratio of acceptable reproducibility(S_r) versus repeatability(S_w) was chosen to provide a goal for interlaboratory reproducibility. A ratio $(S_r/S_w)^2$ exceeding 2.3 (i.e. 1.5^2) would be considered significant with a risk of error of less than 10% , 5% and 1% respectively for 10, 20, and 35 degrees of freedom. Results that exceed warning and control limits determined from this desired maximum interlaboratory reproducibility(S_r) are deemed to be possibly or probably biased respectively. Since the reproducibility S_r is 1.5 times the repeatability S_w, the warning and control limits for bias are set at $3S_w$ and $4.5S_w$ respectively.

The term 'acceptable' throughout the evaluation is based on the observed performance of those participants reporting comparable data. In some cases closer scrutiny of the plotted results suggests that the limits could have been tightened. This was not done in this study.

The Youden-style graphical presentation enables all participants to visualize easily how they performed compared to others. The assessment of a laboratory in this study is based on the location of its results on the graph. The Figure 5.0 identifies the various regions in a typical graph associated with the different types of problems that might be experienced by the participants. Laboratories with controlled repeatability but showing various degrees of bias will appear in the lower left and upper right quadrants. The two circles drawn in this diagram represent the warning limits for repeatability (S_w) and reproducibility (S_r). Those points within the outer circle but in the upper left and lower right quadrants (not shaded in Figure 5.0) are unbiased but somewhat less precise. Those points within the outer circle but in the upper right and lower left quadrants are precise but acceptably biased. Thus the area of acceptable performance in this diagram has taken the shape of a keyhole.

FIGURE 5.0




KEY TO SHADED AREAS
WARNING LIMIT FOR REPEATABILITY (INNER CIRCLE)
AREA OF ACCEPTABLE PERFORMANCE (ALL SHADED AREA)
UNBIASED BUT LESS PRECISE (ALL UNSHADED AREA)
WARNING LIMIT FOR REPRODUCIBILITY (OUTER CIRCLE)
SLOPE BIAS
INTERCEPT BIAS
OUT OF CONTROL

In a typical graphical presentation (Figures 5.1 to 5.18), the actual results of each laboratory constitute the points on the graph. The solid lines dividing the graph into four quadrants represent the target concentration of appropriate samples. The 'keyhole' shaped area of acceptable performance, described earlier, is the area delimited by the inner circle and the outer arcs in the lower left and upper right quadrants. All laboratories that lie outside this area have exceeded the respective warning limits. Two dotted lines are drawn across the graph representing the slope (concentration) dependant error and the intercept (blank) dependant error. The laboratories that exhibit these types of biases will lie along these lines. All laboratories that exceed the warning limits have been identified by their lab codes. These laboratories can readily see the nature of their particular problem. Note that if S_w appears to be concentration dependant, then the data is evaluated in terms of percentage of target.

The Table for each parameter shows the results reported by each participating laboratory along with pertinent statistical information. The "S_w" indicated in these tables represents the average within-laboratory standard deviation (repeatability) estimated for this parameter based on the results of this study as described in section 4.3. The outcome of the evaluation of each laboratory is recorded in the extreme right column. Those laboratories that fall in the warning range (i.e. laboratories that exceed the warning limits but fall within the control limits) are identified with the prefix Warning followed by the type of error. Also included in these tables are estimates of the 'total error' for those participants that have exceeded the

warning and control limits. The **total error** of a laboratory for a particular test is the distance, in units of S_w, from the point representing its results in the appropriate graph to the point of intersection of the two target lines. Also revealed in these tables is the fact that the observed mean values are essentially equal to the target values. In other words one may conclude that the data produced by competent laboratories are on average accurate.

Most of the participants reported their analytical procedures for metal analysis. Concentrated nitric acid was employed by the majority of the laboratories for the digestion (59%). 29% of the participants used aqua regia. Two laboratories did not digest their metal samples. Plasma emission was the popular choice of the majority of laboratories (57%) followed by conventional Atomic Absorption, AA, (36%). Hydride generation followed by AA was used by most participants for the analysis of Arsenic and Selenium. A summary of the analytical methods employed in this study (table 9.1 and 9.2, Appendix 2) did not reveal any correlation between the analytical procedure (digestion and/or instrumentation) and the biases identified for most parameters, for these simple matrix samples.

An overview of performance of each laboratory for the each test is presented in tables 5.1.to 5.4. The key to these summary tables is as follows:

A	Acceptable performance
Li	Biased low, Possible intercept problem
LI	Biased low, Probable intercept problem
Ls	Biased low, Possible slope problem
LS	Biased low, Probable slope problem
L	Biased low
Le	Biased low and/or erratic
Hi	Biased high, Possible intercept problem
HI	Biased high, Probable intercept problem
Hs	Biased high, Possible slope problem
HS	Biased high, Probable slope problem
H	Biased high
He	Biased high and/or erratic
OC	Out of control - one result erratic
ER	Both results erratic
WAI	Warning: Slight imprecision
WLI	Warning: Biased low, Probable intercept problem
WLS	Warning: Biased low, Probable slope problem
WHI	Warning: Biased high, Probable intercept problem
WHS	Warning: Biased high, Probable slope problem
WOC	Warning: Out of control - one result erratic
WER	Warning: Both results erratic

TABLE 5.1

MOE INTER-LABORATORY STUDY 89-6
SUMMARY OF INDIVIDUAL LABORATORY PERFORMANCE
MISA TEST GROUP 9 METALS

LAB CODE	Al	B	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
3001	OC	A	A	A	A	A	WHS	A	A	A	A	A	A
3002	A	A	A	A	A	A	WHS	A	WHS	A	A	A	A
3003	A	WHS	A	A	A	A	A	A	A	HI	A	A	A
3004	A	A	A	A	A	A	A			A	He	A	A
3005	A	A	A	A	A	A	A	A	A	A	A	WHS	A
3006	A	Ls	A	Hs	A	A	HS	A	A	A	A	A	A
3010	A			WLS	A	WAI	WOC	A	A	WHI	A		A
3011	OC			A	A	A	A	A	A	A	A	A	A
3013	A	HS	A	A	A	A	A	A	A	A	A	A	A
3014						A							WLS
3015	HI		OC	A	A	Hs	A	A	WHI	A	A		A
3016	A		A	A	A	A	A	A	A	A	A		A
3017	A	A	WLS	WLI	A	A	A	A		A	A	A	OC
3018	A	OC	A	LS	A	A	A	A	A	ER	A	A	A
3019	A	A	A	A	A	A	A	A	HS	A	A	A	WLS
3022						LS							A
3023	A	A	A	A	A	A	A	A	A	A	A	A	A
3024	LI			A	Ls	A	A	LS	A	WAI	OC		A
3025	LS	LS	Ls	LS	LS	A	WLS			LS	LS	LS	LS
3027	A	WLS	WHS	A	WHI	WHS	A	A	WHS	HS	HS	A	WHS
3028	LS	A	WHS	WHS	WHS	A	WAI	A	HS	WOC	HS	A	WHS
3029	WAI	A	A	WHS	A	A	A	A	WHS	HS	HS	A	A
3032					A	OC	A	A	A	A			A
3034						ER							WHI
3035	HI	A	LS	WLI	WLS	A	A	ER	A	OC	A	OC	A
3036	A	A	WLS	A	A	A	A	A	A	A	A	A	A

TABLE 5.2

MOE INTER-LABORATORY STUDY 89-6
SUMMARY OF TYPES OF PROBLEMS
MISA TEST GROUP 9 METALS

	Al	B	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
TOTAL LABS	22	17	19	22	23	26	23	21	20	23	22	18	26
A	14	11	12	14	18	20	17	19	14	14	16	15	19
AI													
W	1	2	4	5	3	2	5		4	3		1	5
HS		1					1		2	2	3		
HI	2									1			
Hi													
Hs				1		1							
H													
LS	2	1	1	2	1	1		1		1	1	1	1
Ls		1	1		1								
LI	1												
Li													
L													
OC	2	1	1			1				1	1	1	1
ER						1		1		1			
He											1		

TABLE 5.3

MOE INTER-LABORATORY STUDY 89-6
SUMMARY OF INDIVIDUAL LABORATORY PERFORMANCE
MISA TEST GROUP 4A, 6, 10 & 14

CODE	As	Se	Total Phos	Total Kjeldahl Nitrogen	Phenolics (4AAP)
3001	A	WHI	A	A	A
3002	A	A	Li	LS	A
3003	A	A	A	WLS	A
3004	A			ER	OC
3005	A	A	OC	A	WAI
3006	WOC	A	LS	WAI	Ls
3007			A	A	A
3008			A		A
3009			A	A	WOC
3010	LI		A	Ls	LS
3011	WHS		A	A	LI
3013	A	OC	A	A	A
3014			LS		LI
3015			He		ER
3016			A	A	WLI
3018	WLS	LS			ER
3019	HS	A	A	A	A
3021					LS
3022					LI
3023	A	A			
3024			A	WAI	Le
3025					A
3026			A		WLI
3027	A	WOC		ER	A
3028	A	A	WLS	A	A
3029	A	A	WAI	Ls	
3030			A	A	
3031			HS		L
3032			A	A	HI
3033			LS		Hi
3034			A		OC
3035	A	A			Li
3036			LS		H

TABLE 5.4

MOE INTER-LABORATORY STUDY 89-6
SUMMARY OF TYPES OF PROBLEMS
MISA TEST GROUP 4A, 6, 10 & 14

	As	Se	Total Phos.	Total Kjeldahl Nitrogen	Phenolics (4AAP)
Total labs	16	13	25	19	30
A	11	9	15	11	10
AI					
W	3	2	2	3	4
HS	1		1		
HI					1
Hi					1
Hs					
LS		1	4	1	2
Ls				2	1
LI	1				3
Li			1		1
OC		1	1		2
ER				2	2
H					1
L					1
He			1		
					1

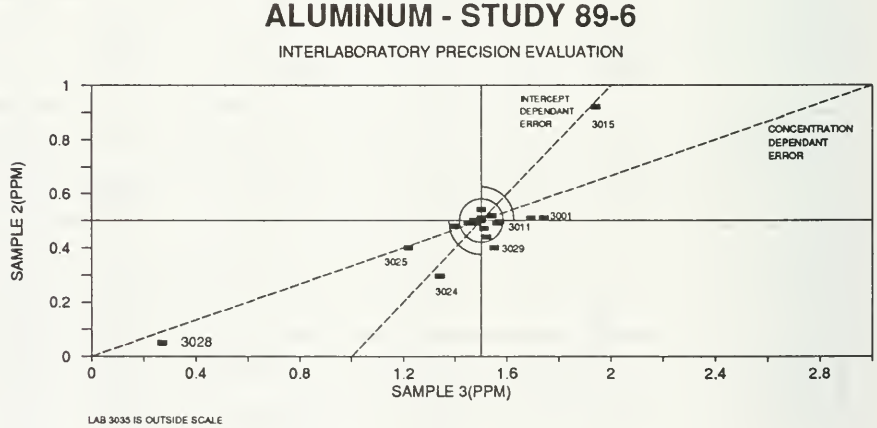
In the following discussion of individual parameters, the nature pf the bias encountered have been identified where ever possible. Concentration dependant biases (slope biases) are caused by either inaccurate standards or improper calibration procedure. Blank problems will result in biases that are not dependant on the concentration (intercept biases). Erratic data are often produced by analytical system not being in control.

5.1.1 ALUMINUM

Table 5.5.1 & Figure 5.1

22 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
14 laboratories produced results of acceptable performance.
Of the other 8 laboratories 7 exceeded the control limits.
Laboratories 3025 & 3028 exhibited slope bias.
Laboratories 3015, 3024, & 3035 (outside scale in Figure 5.1) exhibited intercept bias.
Laboratories 3001 & 3011 were out of control.

FIGURE 5.1

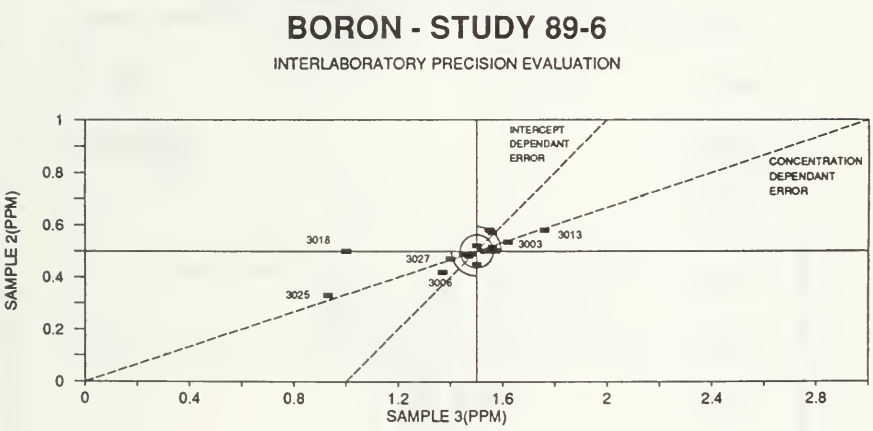


5.1.2 BORON

Table 5.5.2 & Figure 5.2

17 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
11 laboratories produced results of acceptable performance.
Of the other 6 laboratories 4 exceeded the control limits.
Laboratories 3006, 3013 & 3025 exhibited slope bias.
Laboratory 3018 was out of control.

FIGURE 5.2

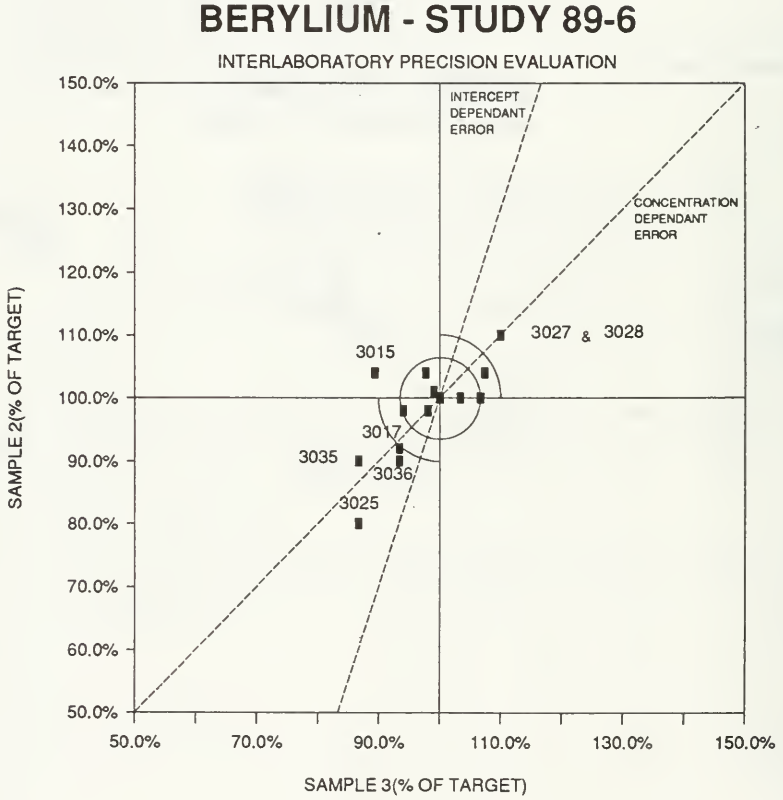


5.1.3 BERYLIUM

Table 5.5.3 & Figure 5.3

19 laboratories reported results. The repeatability among selected laboratories was concentration dependant.
12 laboratories produced results of acceptable performance.
Of the other 7 laboratories 3 exceeded the control limits.
Laboratories 3025 & 3035 exhibited slope bias.
Laboratory 3015 was out of control.

FIGURE 5.3

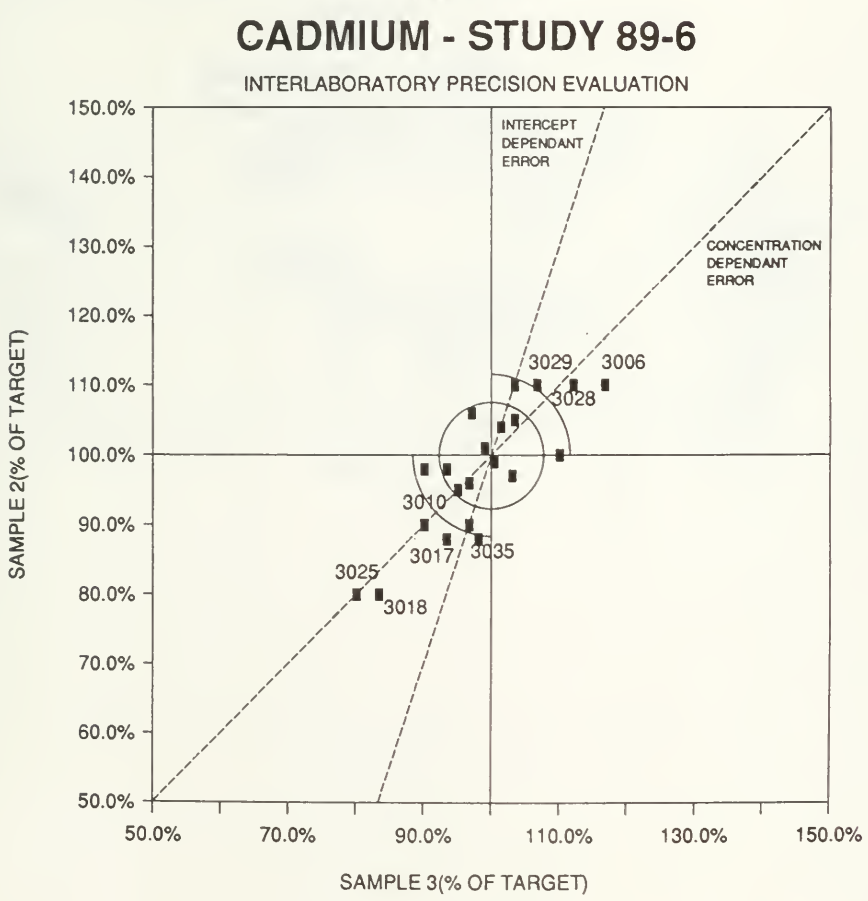


5.1.4 CADMIUM

Table 5.5.4 & Figure 5.4

22 laboratories reported results. The repeatability among selected laboratories was concentration dependant.
14 laboratories produced results of acceptable performance.
Of the other 8 laboratories 3 exceeded the control limits.
Laboratories 3006, 3018 & 3025 exhibited slope bias.

FIGURE 5.4

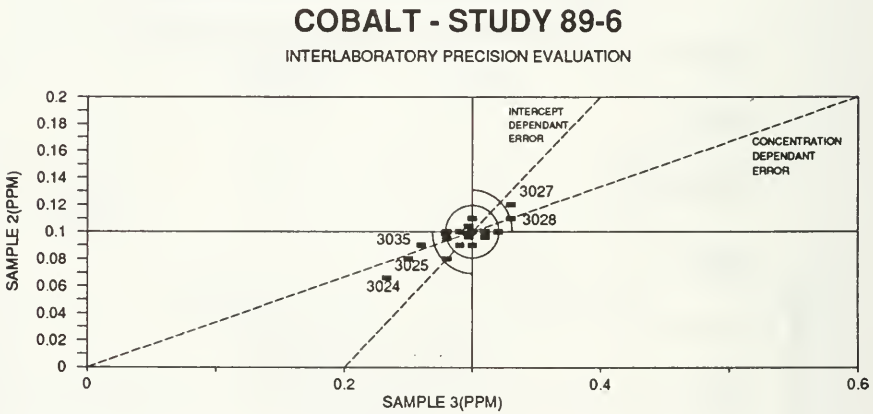


5.1.5 COBALT

Table 5.5.5 & Figure 5.5

23 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
18 laboratories produced results of acceptable performance.
Of the other 5 laboratories 2 exceeded the control limits.
Laboratories 3024 & 3025 exhibited slope bias.

FIGURE 5.5

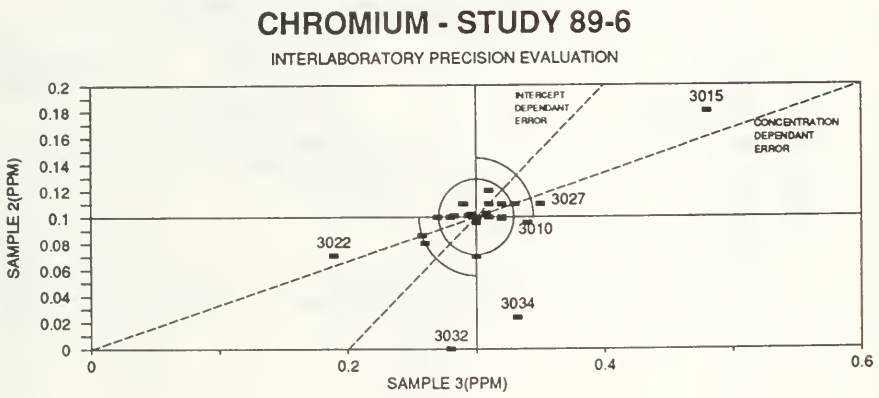


5.1.6 CHROMIUM

Table 5.5.6 & Figure 5.6

26 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
20 laboratories produced results of acceptable performance.
Of the other 6 laboratories 4 exceeded the control limits.
Laboratories 3015 & 3022 exhibited slope bias.
Laboratory 3032 was out of control.
Laboratory 3034 reported erratic data.

FIGURE 5.6

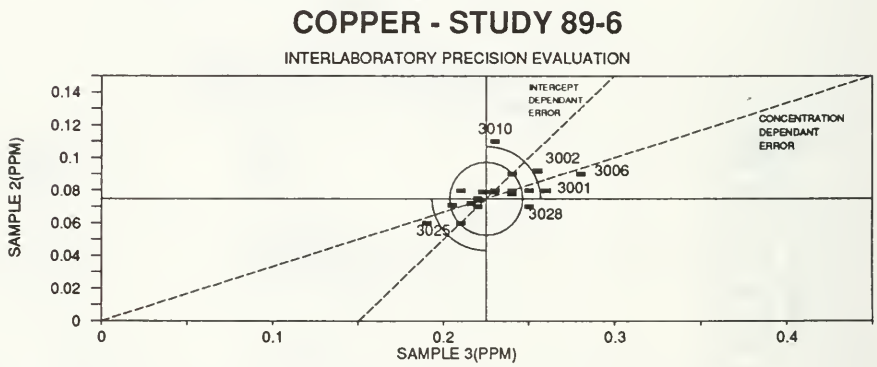


5.1.7 COPPER

Table 5.5.7 & Figure 5.7

23 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
17 laboratories produced results of acceptable performance.
Of the other 6 laboratories only 1 exceeded the control limits.
Laboratory 3006 exhibited slope bias.

FIGURE 5.7

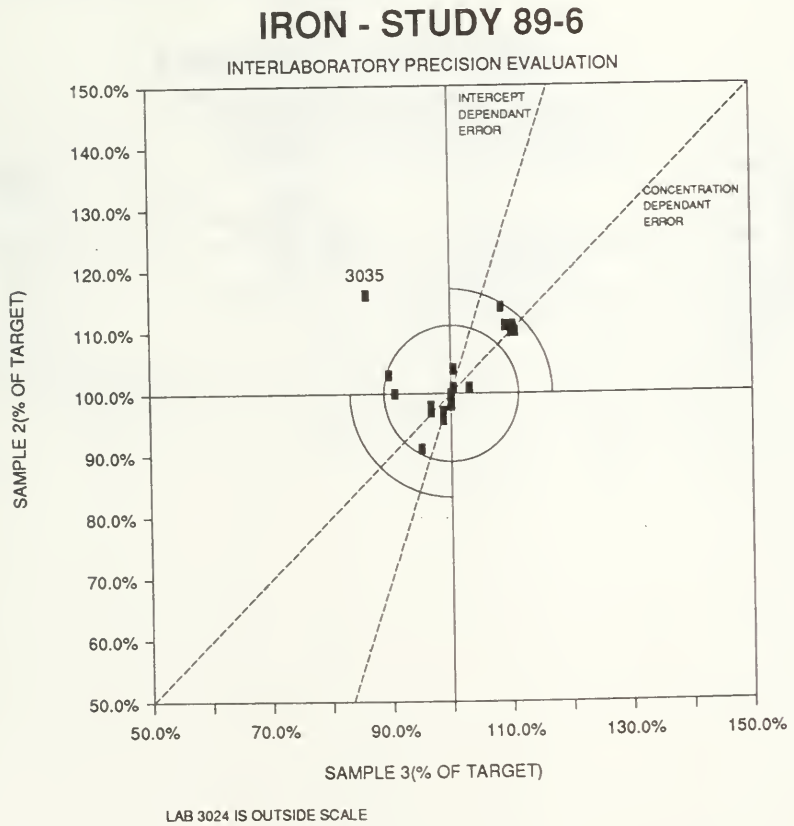


5.1.8 IRON

Table 5.5.8 & Figure 5.8

21 laboratories reported results. The repeatability among selected laboratories was concentration dependant.
19 laboratories produced results of acceptable performance.
The other 2 laboratories exceeded the control limits.
Laboratory 3024 (outside scale in Figure 5.8) exhibited slope bias.
Laboratory 3035 reported erratic data.

FIGURE 5.8

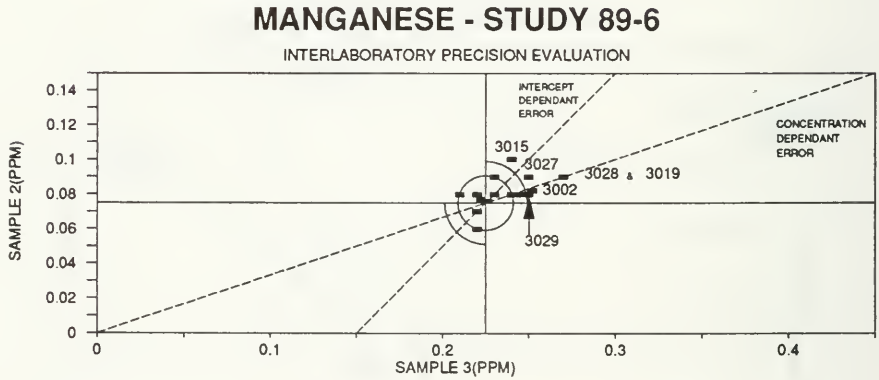


5.1.9 MANGANESE

Table 5.5.9 & Figure 5.9

20 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
14 laboratories produced results of acceptable performance.
Of the other 6 laboratories 2 exceeded the control limits.
Laboratories 3019 & 3028 exhibited slope bias.

FIGURE 5.9

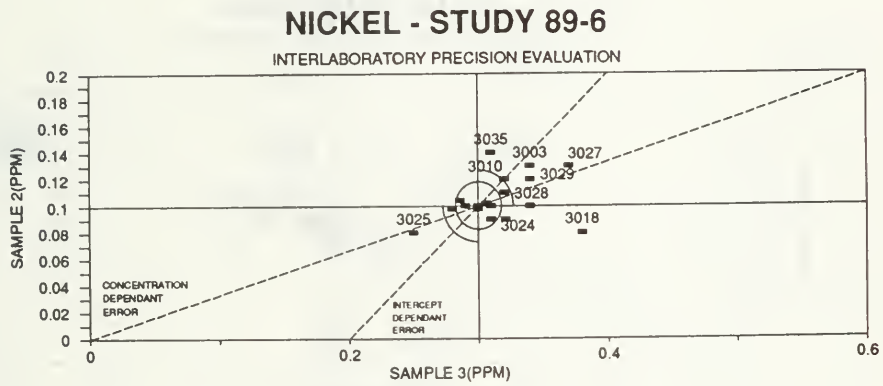


5.1.10 NICKEL

Table 5.5.10 & Figure 5.10

23 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
14 laboratories produced results of acceptable performance.
Of the other 9 laboratories 6 exceeded the control limits.
Laboratories 3025 3027 & 3029 exhibited slope bias.
Laboratory 3003 exhibited intercept bias.
Laboratory 3035 was out of control.
Laboratory 3018 reported erratic data.

FIGURE 5.10

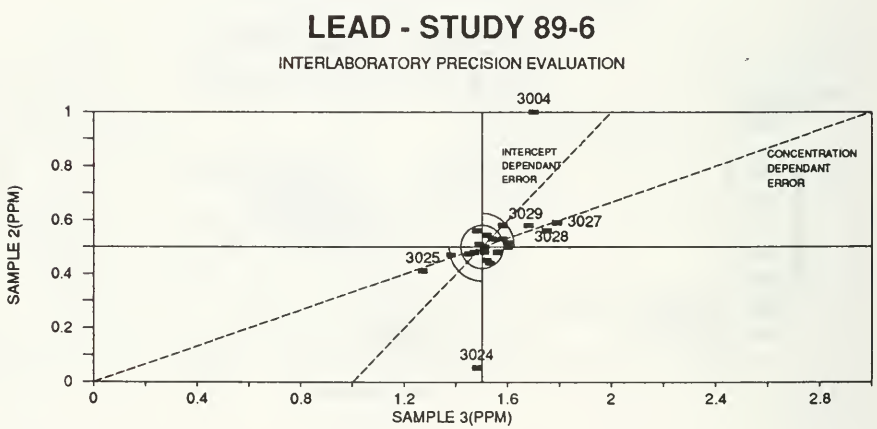


5.1.11 LEAD

Table 5.5.11 & Figure 5.11

22 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
16 laboratories produced results of acceptable performance.
The other 6 laboratories exceeded the control limits.
Laboratories 3025 3027 3028 & 3029 exhibited slope bias.
Laboratory 3024 was out of control.
Laboratory 3004 produced highly biased and erratic data.

FIGURE 5.11

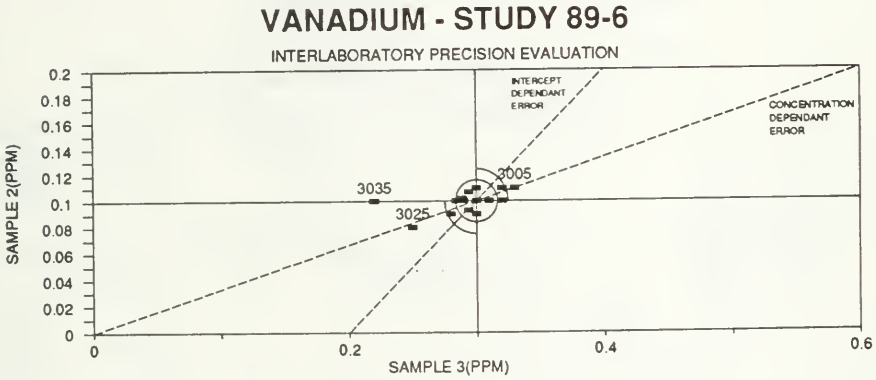


5.1.12 VANADIUM

Table 5.5.12 & Figure 5.12

18 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
15 laboratories produced results of acceptable performance.
Of the other 3 laboratories 2 exceeded the control limits.
Laboratory 3025 exhibited slope bias.
Laboratory 3035 was out of control.

FIGURE 5.12

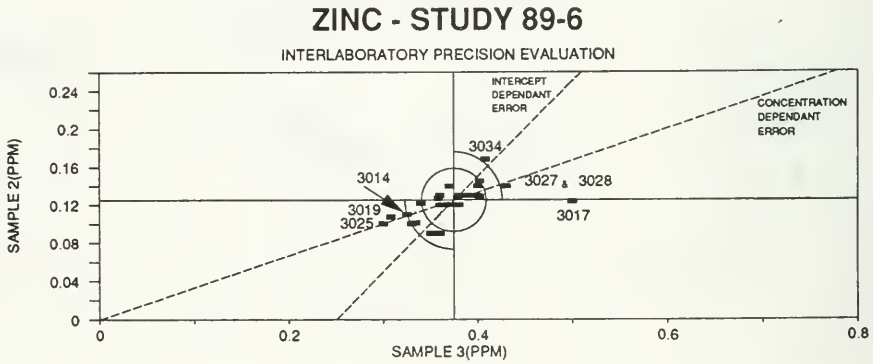


5.1.13 ZINC

Table 5.5.13 & Figure 5.13

26 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
19 laboratories produced results of acceptable performance.
Of the other 7 laboratories 2 exceeded the control limits.
Laboratory 3025 exhibited slope bias.
Laboratory 3017 was out of control.

FIGURE 5.13

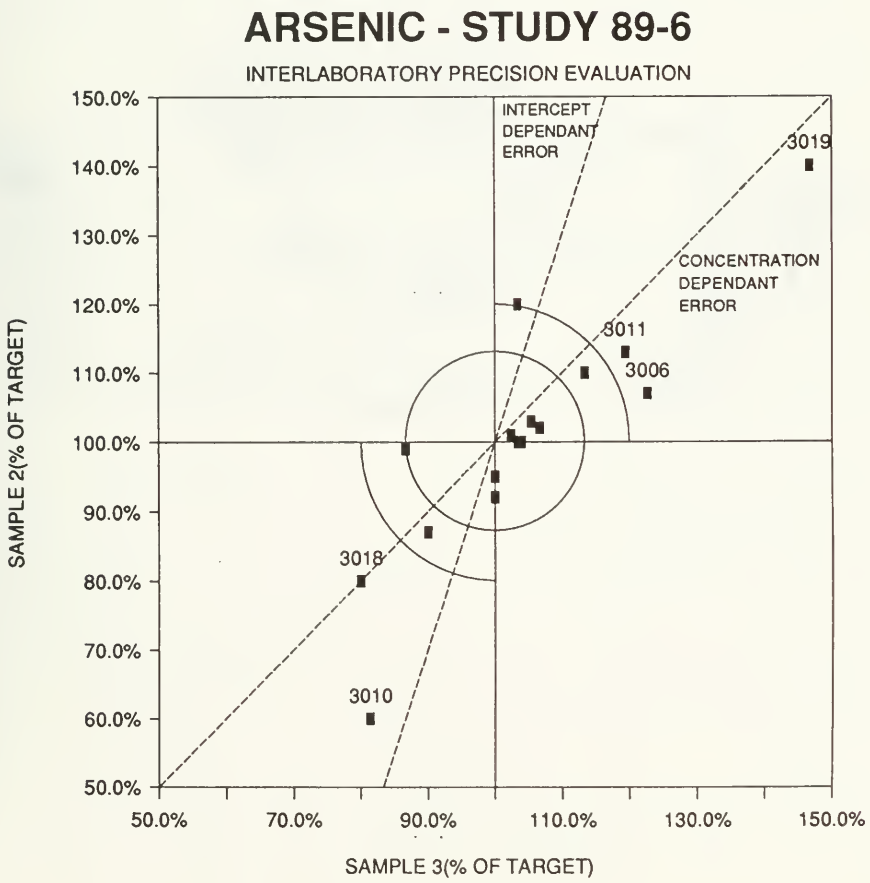


5.1.14 ARSENIC

Table 5.5.14 & Figure 5.14

16 laboratories reported results. The repeatability among selected laboratories was concentration dependant.
11 laboratories produced results of acceptable performance.
Of the other 5 laboratories 2 exceeded the control limits.
Laboratory 3019 exhibited slope bias.
Laboratory 3010 exhibited intercept bias.

FIGURE 5.14

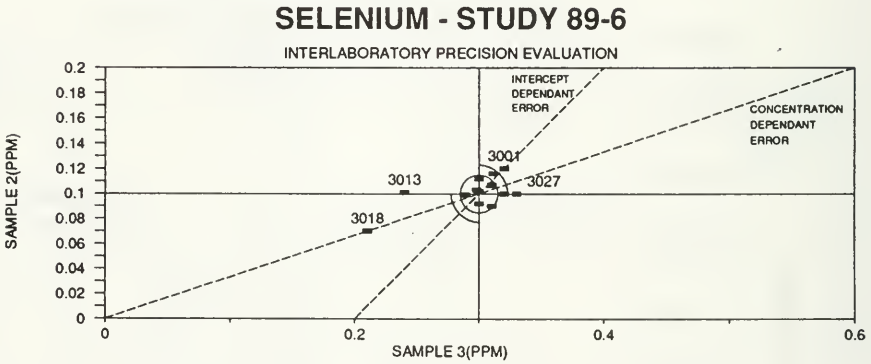


5.1.15 SELENIUM

Table 5.5.15 & Figure 5.15

13 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
9 laboratories produced results of acceptable performance.
Of the other 4 laboratories 2 exceeded the control limits.
Laboratory 3018 exhibited slope bias.
Laboratory 3013 was out of control.

FIGURE 5.15

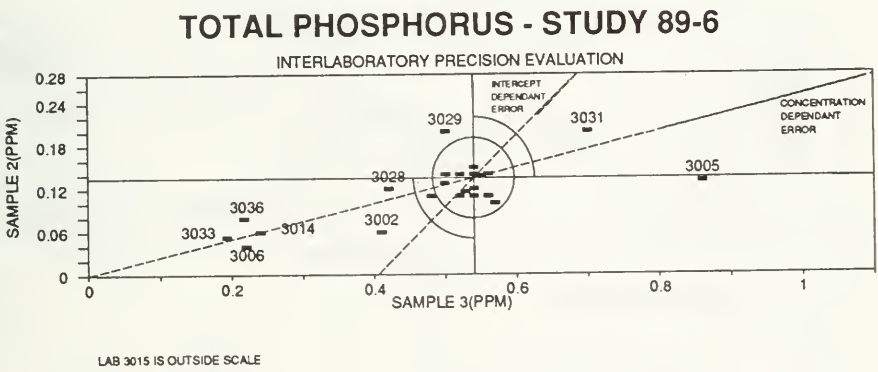


5.1.16 TOTAL PHOSPHORUS

Table 5.5.16 & Figure 5.16

25 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
15 laboratories produced results of acceptable performance.
Of the other 10 laboratories 8 exceeded the control limits.
Laboratories 3006, 3014, 3031,3033 & 3036 exhibited slope bias.
Laboratory 3002 exhibited intercept bias.
Laboratory 3005 was out of control.
Laboratory 3015 (outside scale in Figure 5.16) produced highly biased and erratic data.

FIGURE 5.16



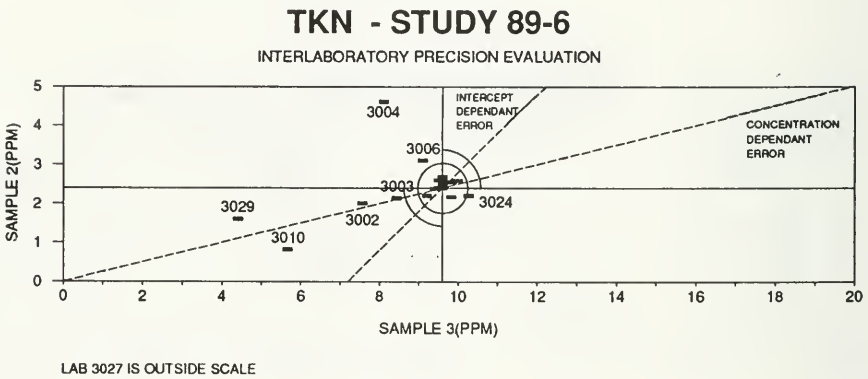
LAB 3015 IS OUTSIDE SCALE

5.1.17 TOTAL KJELDAHL NITROGEN (TKN)

Table 5.5.17 & Figure 5.17

19 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
11 laboratories produced results of acceptable performance.
Of the other 8 laboratories 5 exceeded the control limits.
Laboratories 3002, 3010 & 3029 exhibited slope bias.
Laboratories 3004 & 3027 (outside scale in Figure 5.17) produced erratic data.

FIGURE 5.17



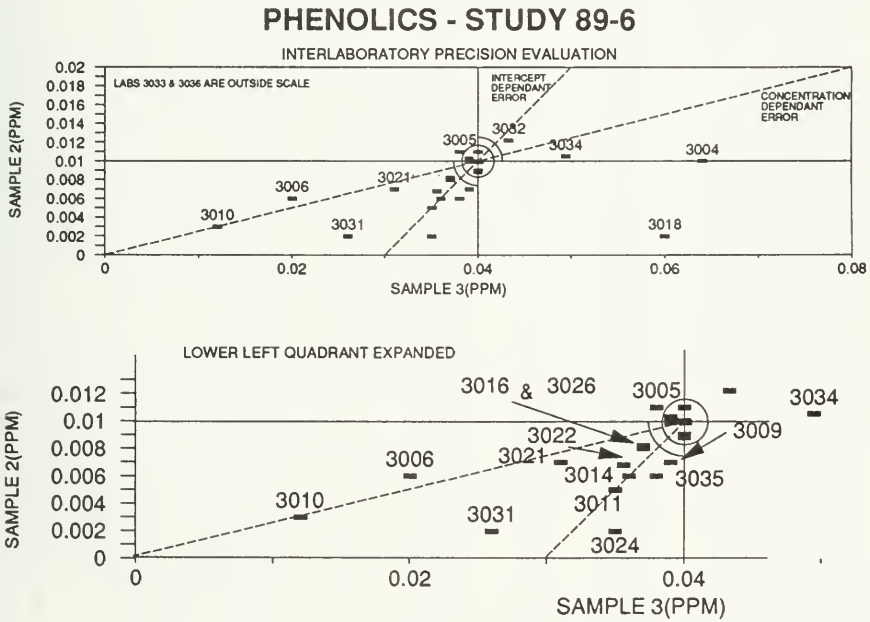
LAB 3027 IS OUTSIDE SCALE

5.1.18 PHENOLICS (4AAP)

Table 5.5.18 & Figure 5.18

30 laboratories reported results. The repeatability among selected laboratories was not concentration dependant.
10 laboratories produced results of acceptable performance.
Of the other 20 laboratories 16 exceeded the control limits.
Laboratories 3006, 3010 & 3021 exhibited slope bias.
Laboratories 3011, 3014, 3022, 3032, 3033 (outside scale in Figure 5.18) & 3035 exhibited intercept bias.
Laboratories 3004 & 3034 were out of control.
Laboratories 3015, & 3018 produced erratic data.
Laboratories 3031, 3036 (outside scale in Figure 5.18) and 3024 exhibited poor precision in addition to biases. Hence the nature of the biases were unidentifiable.

FIGURE 5.18



5.2 OVERALL ASSESSMENT OF LABORATORY PERFORMANCE

The overall performance of participating laboratories is summarized in the Table 5.6. This table includes the total number of tests reported by each laboratory, the percentage of this total that were within the limits of acceptable performance, and the percentages that exceeded the warning and control limits. Also incorporated in this table is the overall assessment of each laboratory. Laboratories which produced results of acceptable performance for more than ninety percent of the tests analyzed, are appraised as excellent. Five participants in this study earned this distinction. Those that produced results of acceptable performance for between eighty and ninety percent of the tests were graded as good. Eight laboratories were assessed as good. Laboratories that produced results of acceptable performance for sixty to eighty percent of the tests were graded as moderate. Six participants were placed in this group. Those laboratories that produced results of acceptable performance for thirty to sixty percent of the tests and those that produced below thirty percent of the tests were graded as poor and very poor respectively. Nine laboratories were assessed as poor and another six as very poor.

TABLE 5.6
SUMMARY OF OVERALL LABORATORY PERFORMANCE

CODE	TOTAL # OF TESTS	ACCEPTABLE PERFORMANCE (AS % OF TOTAL)	TESTS WITHIN THE WARNING RANGE (AS % OF TOTAL)	TESTS EXCEEDING CONTROL LIMITS (AS % OF TOTAL)	OVERALL ASSESSMENT
3001	18	83%	11%	6%	GOOD
3002	18	78%	11%	11%	MODERATE
3003	18	83%	11%	6%	GOOD
3004	14	79%	0%	21%	MODERATE
3005	18	83%	11%	6%	GOOD
3006	18	61%	11%	28%	MODERATE
3007	3	100%	0%	0%	EXCELLENT
3008	2	100%	0%	0%	EXCELLENT
3009	3	67%	33%	0%	MODERATE
3010	14	50%	29%	21%	POOR
3011	15	80%	7%	13%	GOOD
3013	18	89%	0%	11%	GOOD
3014	4	25%	25%	50%	VERY POOR
3015	13	54%	8%	38%	POOR
3016	14	93%	7%	0%	EXCELLENT
3017	12	75%	17%	8%	MODERATE
3018	16	63%	6%	31%	MODERATE
3019	18	83%	6%	11%	GOOD
3021	1	0%	0%	100%	VERY POOR
3022	3	33%	0%	67%	POOR
3023	15	100%	0%	0%	EXCELLENT
3024	13	46%	15%	38%	POOR
3025	12	17%	8%	75%	VERY POOR
3026	2	50%	50%	0%	POOR
3027	17	41%	41%	18%	POOR
3028	18	44%	39%	17%	POOR
3029	17	59%	24%	18%	POOR
3030	2	100%	0%	0%	EXCELLENT
3031	2	0%	0%	100%	VERY POOR
3032	10	80%	0%	20%	GOOD
3033	2	0%	0%	100%	VERY POOR
3034	4	25%	25%	50%	VERY POOR
3035	16	50%	13%	38%	POOR
3036	15	80%	7%	13%	GOOD

6 BIBLIOGRAPHY

1. Ontario Regulation 695/88 under the Environmental Protection Act; Effluent Monitoring General.
2. Classification of Systematic Errors using Two Samples at Different Concentrations, D.E.King, S.S.Selliah, *in preparation.*

7 APPENDIX 1- LIST OF PARTICIPANTS & CORRESPONDENCE

LIST OF PARTICIPANTS

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MOE INTERLABORATORY VARIABILITY STUDY NOTIFICATION FOR THE ANALYIS OF TRACE INORGANIC COMPOUNDS

STUDY NO. 89-6

INTRODUCTION

Laboratories receiving this notification are invited by the Ontario Ministry of the Environment, Laboratory Services Branch, to participate in an interlaboratory variability study of spiked reagent water conducted using MISA analysis protocols. Laboratories interested in participating in this program, scheduled for the week of September 25, 1989, should contact Sylvia Cussion at (416) 235-5842 or Catherine Doehler (416) 235-6055 of the Ministry of the Environment to confirm participation. Written confirmation (attached response sheet) must be submitted to the Ministry of the Environment no later than September 18, 1989 (FAX - (416) 235-5744).

BACKGROUND

This study is being conducted to assist laboratories in assessing their analytical performance. All procedures should follow those principles and protocols outlined in the MISA regulations (Ontario Reg. 358/88). Sample sets will include three samples per test group: a blank, a low spike (approx. 5 times the Regulation MDL) and a high spike (approx. 20 times the Regulation MDL).

NOTE: Any laboratory that does not have a copy of the MISA general regulations should contact Catherine Doehler for additional information.

The following test groups are to be included in this round robin:

Total Metals and Hydrides
(MISA Groups 9 and 10)

Time Limit: 30 days storage

Aluminum (Al)	Chromium (Cr)	Manganese (Mn)
Beryllium (Be)	Copper (Cu)	Nickel (Ni)
Boron (B)	Iron (Fe)	Vanadium (V)
Cadmium (Cd)	Lead (Pb)	Zinc (Zn)
Cobalt (Co)		
Arsenic (As)	Selenium (Se)	

NOTE: The spiking material to be used for this study contains parameters that are not in MISA Test Groups 9 and 10.

Total Kjeldahl Nitrogen and Total Phosphorus
(MISA Groups 4a and 6)

Time Limit: 28 days storage
Samples will be shipped preserved with nitric acid.

Phenolics (4AAP)
(MISA Group 14)

Time Limit: 4 days storage
Samples will be preserved with H_2SO_4.

SCHEDULE

During the week of September 25, 1989 participating laboratories will receive a total of nine (9) samples divided as follows: three (3) for the analysis of Total Metals and Hydrides, three (3) for the analysis of Total Kjeldahl Nitrogen and Total Phosphorus, and three (3) for the analysis of Phenolics by 4AAP. All samples will be spiked reagent water samples.

Participating laboratories are expected to analyze the samples within the time limits specified in Schedule 2 of the general MISA regulations (Ontario Reg. 358/88). Blank reporting forms will be provided with the samples. Results for all analyses are to be reported within forty (40) days of receipt of the samples to Sylvia Cussion/Catherine Doehler at the following address:

Ministry of the Environment
Laboratory Services Branch
Laboratory Computer Systems - QA/QC Section
125 Resources Rd., P.O. Box 213
Rexdale, Ontario
M9W 5L1

SUMMARY OF RESULTS

All participating laboratories will be assigned a unique identification code. All laboratories will receive a complete set of the results, including a ranking for each laboratory where they will be identified only by their identification code. Recommendations made by the MOE will also be provided to the individual labs. Results will remain confidential and will only be released with the written permission of the individual participants.

It is the intent of this round robin (along with others) to assess the interlaboratory variability and detection capability for a broad range of organics and inorganics.

MOE INTERLABORATORY VARIABILITY STUDY NOTIFICATION FOR THE ANALYIS OF TRACE INORGANIC COMPOUNDS

STUDY NO. 89-6

Yes, we will participate in MOE Study 89-6 for the following tests:	YES	NO
Total Metals and Hydrides	☐	☐
Total Kjeldahl Nitrogen and Total Phosphorus	☐	☐
Phenolics by 4AAP	☐	☐
No, we will not participate in MOE Study 89-6		☐

For the completeness of our records, and to avoid any shipping delays, please fill in the following:

Mailing Address: Shipping Address:

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

Contact Person: _____

Phone Number: _____

Please return this questionnaire before September 18, 1989 to:

Sylvia Cussion/Catherine Doehler
Ontario Ministry of the Environment
Laboratory Services Branch
LCS-QA/QC Section
125 Resources Rd.
Rexdale, Ontario
M9W 5L1

(416) 235-5842 or 235-6055

Laboratory Services Branch
Quality Assurance Unit
125 Resources Rd.
Rexdale, Ontario
M9W 5L1
(416) 235-5842 or 235-6055
FAX (416) 235-5744

September 25, 1989.

TO: PARTICIPANTS OF MOE INTERLABORATORY STUDY 89-6

Please find enclosed nine bottles, three for metals analysis, three for total nutrient analysis, and three for phenolicss (by 4-AAP) analysis. The samples are labelled as follows:

For Metals:	MET1	MET2	MET2
For TKN/TP:	NUT1	NUT2	NUT3
For Phenolics:	PHN1	PHN2	PHN3

Please note that the samples are preserved with the following:

Metals: Nitric Acid
TKN/TP: Sulphuric Acid
Phenolics:Sulphuric Acid

For those participants analyzing for only some of the metals, please cross out the elements that cannot be reported. If you are missing any of the above items, please contact us at the above phone number immediately.

Your participation in MOE Interlaboratory Study 89-6 is greatly appreciated by the Laboratory Services Branch of the Ministry of the Environment.

As stated in the notification distributed August 25, 1989, samples should be analyzed using the principles and protocols outlined in the MISA general regulation (Ontario Reg. 358/88). Store all samples in a refrigerator at 4 degrees Celcius until ready for analysis. Time limits for storage were indicated in the advance notification.

To ensure timely release of a summary report, results are to be reported within forty (40) days of reception of the samples. Results will not be accepted after November 10, 1989. Report forms

to be used are included with the samples. Please identify all sample results with your lab identification number and the sample numbers described above. Please contact us if there are any problems or questions re the interlaboratory study.

Your lab identification number is:

Sincerely,

Sylvia Cussion
Lab Quality Audit Scientist
(416) 235-5842

Catherine Doehler
MISA Audit Scientist
(416) 235-6055

Ontario Ministry of the Environment
Laboratory Services Branch
Quality Assurance Unit
125 Resources Rd.
Rexdale, Ontario
M9W 5L1

(416) 235-5842

December 4, 1989.

TO: PARTICIPANTS OF MOE INTERLABLABORATORY STUDY 89-6

Thank you for your participation in the MOE Interlaboratory Study 89-6 conducted in September 1989 for the analysis of metals (MISA Group 9), hydrides (MISA Group 10), phenolics (MISA Group 14), and total nutrients (MISA Groups 4a and 6). Your participation is greatly appreciated by the Ministry of the Environment.

Attached are all the results reported to me as of November 22, 1989. Not all the original participants were able to report results. Listed for each sample and parameter are the target values, the results reported by each participant, the mean, median, and the standard deviation. For labs that did not report a result for a specific parameter for all samples, the space has been left blank. For labs that reported results for a parameter, but did not report a result in a particular sample, the result was reported as "0". All participants are identified only by their identification code.

A formal report is presently being written, but I regret that it will not be completed until the summer of 1990. All participants will receive a copy as soon as it becomes available.

Please contact me if you have any further questions.

Sincerely,

Sylvia Cussion
Laboratory Quality Audit Scientist

Attachment

8 APPENDIX 2-SUMMARY OF ANALYTICAL METHODOLOGY USED

TABLE 9.1
SUMMARY OF DIGESTION ACIDS USED

CODE	GROUP 9		GROUP 10	
	Al,Be,Cd,Co,Cr,Cu,Fe,Mn,Ni,Pb,V,Zn	B	As	Se
3001	Aqua regia	None	$HNO_3/H_2SO_4/HClO_4$	
3002	HNO_3	HNO_3	HNO_3/H_2SO_4	
3003	HNO_3	HNO_3	HNO_3	HNO_3
3004	No Information			
3005	HNO_3	HNO_3	HNO_3	HNO_3
3006	HNO_3	HNO_3	HNO_3/H_2SO_4	HNO_3
3010	Aqua regia		Aqua-regia	
3013	Aqua regia	Aqua-regia	Aqua-regia	Aqua-regia
3014	HNO_3			
3015	HNO_3			
3016	HNO_3			
3017	Aqua regia + HNO_3	None		
3018	None	None	None	None
3019	Aqua regia + HNO_3			
3022	HNO_3			
3023	Aqua regia	None	HNO_3/H_2SO_4	HNO_3/H_2SO_4
3024	HNO_3			
3025	HNO_3	HNO_3		
3027	HNO_3	HNO_3	HNO_3	HNO_3
3028	HNO_3	HNO_3	HNO_3	HNO_3
3029	None	None	None	None
3032	HNO_3			
3035	No Information			
3036	None	None		

TABLE 9.2
SUMMARY OF INSTRUMENTAL METHODS USED

code	Al	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn	B	As	Se
3001	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	HAA	HAA
3002	PE	PE	AA	PE	PE	PE	PE	PE	PE	AA	PE	AA	PE	HAA	HAA
3003	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	HAA	HAA
3004	NO INFORMATION														
3005	PE, AA, GFA: NO INDIVIDUAL TESTS IDENTIFIED														
3006	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	HAA	GFA
3010	AA		AA	AA	AA	AA	AA	AA	AA	AA		AA		AA	
3013	PE, HAA: NO INDIVIDUAL TESTS IDENTIFIED														
3014					AA							AA			
3015	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA		AA			
3016	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA		AA			
3017	PE	PE	PE	PE	PE	PE	PE		PE	PE	PE	PE	PE		
3018	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	HAA	GFA
3019	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	COL	HAA	HAA
3022					AA							AA			
3023	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	HAA	HAA
3024	AA		AA	AA	AA	AA	AA	AA	AA	AA		AA			
3025	PE	PE	PE	PE	PE	PE		PE	PE	PE	PE	PE	PE		
3027	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE
3028	AA	AA	GFA	PE	PE	AA	PE	PE	AA	GFA	AA	AA	PE	GFA	GFA
3029	GFA	AA	GFA	GFA	GFA	GFA	AA	AA	GFA	GFA	AA	AA	AA	HAA	HAA
3032				AA	AA	AA	AA	AA	AA			AA			
3005	NO INFORMATION														
3036	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE		

PE	PLASMA EMISSION
AA	CONVENTIONAL ATOMIC ABSORPTION
GFA	GRAPHITE FURNACE ATOMIC ABSORPTION
HAA	HYDRIDE GENERATION ATOMIC ABSORPTION
COL	COLORIMETRIC USING CARMINE REAGENT

9 APPENDIX 3- SUMMARY OF DATA FOR ALL PARTICIPANTS

TABLE 5.5.1

MOE INTERLABORATORY STUDY MOE89/6 ALUMINUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.51	1.74	5.7	ONE RESULT ERRATIC
3002	0.518	1.54		ACCEPTABLE PERFORMANCE
3003	0.5	1.47		ACCEPTABLE PERFORMANCE
3004	0.48	1.4		ACCEPTABLE PERFORMANCE
3005	0.5	1.48		ACCEPTABLE PERFORMANCE
3006	0.49	1.45		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.54	1.5		ACCEPTABLE PERFORMANCE
3011	0.51	1.69	4.5	ONE RESULT ERRATIC
3013	0.44	1.52		ACCEPTABLE PERFORMANCE
3014				
3015	0.92	1.94	14.5	BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3016	0.49	1.56		ACCEPTABLE PERFORMANCE
3017	0.495	1.57		ACCEPTABLE PERFORMANCE
3018	0.5	1.5		ACCEPTABLE PERFORMANCE
3019	0.51	1.5		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.49	1.48		ACCEPTABLE PERFORMANCE
3024	0.296	1.34	6.2	BIASED LOW, PROBABLE INTERCEPT PROBLEM
3025	0.4	1.22	7.1	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.47	1.51		ACCEPTABLE PERFORMANCE
3028	0.05	0.27	31.2	BIASED LOW, PROBABLE SLOPE PROBLEM
3029	0.4	1.55	2.7	WARNING: SLIGHT IMPRECISION
3030				
3031				
3032				
3033				
3034				
3035	10.25	11.28	328.5	BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3036	0.49	1.47		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.500	1.500		
MEDIAN OVERALL	0.493	1.500		SD3/SD2 1.198
MEDIAN SELECTED	0.493	1.500		
MEAN OVERALL	0.478	1.466		Sw 0.042 ppm
MEAN SELECTED	0.485	1.500		
S.OVERALL	0.141	0.295		
S.SELECTED	0.036	0.043		

TABLE 5.5.2

MOE INTERLABORATORY STUDY MOE89/6 BORON

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.57	1.56		ACCEPTABLE PERFORMANCE
3002	0.482	1.47		ACCEPTABLE PERFORMANCE
3003	0.536	1.62	3.9	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3004	0.52	1.5		ACCEPTABLE PERFORMANCE
3005	0.488	1.45		ACCEPTABLE PERFORMANCE
3006	0.42	1.37	4.8	BIASED LOW, POSSIBLE SLOPE PROBLEM
3007				
3008				
3009				
3010				
3011				
3013	0.58	1.76	8.6	BIASED HIGH, PROBABLE SLOPE PROBLEM
3014				
3015				
3016				
3017	0.516	1.56		ACCEPTABLE PERFORMANCE
3018	0.5	1	-15.8	ONE RESULT ERRATIC
3019	0.58	1.55		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.49	1.48		ACCEPTABLE PERFORMANCE
3024				
3025	0.33	0.93	18.7	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.47	1.4	3.3	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3028	0.45	1.5		ACCEPTABLE PERFORMANCE
3029	0.5	1.53		ACCEPTABLE PERFORMANCE
3030				
3031				
3032				
3033				
3034				
3035	0.5	1.57		ACCEPTABLE PERFORMANCE
3036	0.49	1.47		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.500	1.500		
MEDIAN OVERALL	0.500	1.500		SD3/SD2 1.128
MEDIAN SELECTED	0.500	1.500		
MEAN OVERALL	0.495	1.454		Sw 0.032 ppm
MEAN SELECTED	0.495	1.502		
S.OVERALL	0.059	0.198		
S.SELECTED	0.059	0.066		

TABLE 5.5.3

MOE INTERLABORATORY STUDY MOE89/6 BERYLIUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.1	0.3		ACCEPTABLE PERFORMANCE
3002	0.104	0.293		ACCEPTABLE PERFORMANCE
3003	0.101	0.297		ACCEPTABLE PERFORMANCE
3004	0.1	0.31		ACCEPTABLE PERFORMANCE
3005	0.098	0.294		ACCEPTABLE PERFORMANCE
3006	0.1	0.3		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010				
3011				
3013	0.1	0.32		ACCEPTABLE PERFORMANCE
3014				
3015	0.104	0.268	3.4	ONE RESULT ERRATIC
3016	0.104	0.322		ACCEPTABLE PERFORMANCE
3017	0.092	0.28	3.1	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3018	0.1	0.3		ACCEPTABLE PERFORMANCE
3019	0.1	0.3		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.098	0.282		ACCEPTABLE PERFORMANCE
3024				
3025	0.08	0.26	7.2	BIASED LOW, POSSIBLE SLOPE PROBLEM
3026				
3027	0.11	0.33	4.2	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.11	0.33	4.2	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.1	0.31		ACCEPTABLE PERFORMANCE
3030				
3031				
3032				
3033				
3034				
3035	0.09	0.26	5.0	BIASED LOW, PROBABLE SLOPE PROBLEM
3036	0.09	0.28	3.6	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.100	0.300		SD3/SD2 2.999
MEDIAN SELECTED	0.100	0.300		
MEAN OVERALL	0.093	0.297		Sw (% Recovery) 3.330
MEAN SELECTED	0.099	0.297		
S.OVERALL	0.007	0.021		
S.SELECTED	0.007	0.021		

TABLE 5.5.4

MOE INTERLABORATORY STUDY MOE89/6 CADMIUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.096	0.29		ACCEPTABLE PERFORMANCE
3002	0.099	0.301		ACCEPTABLE PERFORMANCE
3003	0.106	0.291		ACCEPTABLE PERFORMANCE
3004	0.11	0.31		ACCEPTABLE PERFORMANCE
3005	0.105	0.31		ACCEPTABLE PERFORMANCE
3006	0.11	0.35	5.1	BIASED HIGH, POSSIABLE SLOPE PROBLEM
3007				
3008				
3009				
3010	0.09	0.27	3.7	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3011	0.101	0.297		ACCEPTABLE PERFORMANCE
3013	0.098	0.27		ACCEPTABLE PERFORMANCE
3014				
3015	0.1	0.33		ACCEPTABLE PERFORMANCE
3016	0.095	0.285		ACCEPTABLE PERFORMANCE
3017	0.088	0.28	3.6	WARNING: BIASED LOW, PROBABLE INTERCEPT PROBLEM
3018	0.08	0.25	6.8	BIASED LOW, PROBABLE SLOPE PROBLEM
3019	0.104	0.304		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.098	0.28		ACCEPTABLE PERFORMANCE
3024	0.097	0.309		ACCEPTABLE PERFORMANCE
3025	0.08	0.24	7.4	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.11	0.31		ACCEPTABLE PERFORMANCE
3028	0.11	0.336	4.1	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.11	0.32	3.1	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3030				
3031				
3032				
3033				
3034				
3035	0.088	0.294	3.2	WARNING: BIASED LOW, PROBABLE INTERCEPT PROBLEM
3036	0.09	0.29		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.099	0.296		SD3/SD2 2.779
MEDIAN SELECTED	0.099	0.296		
MEAN OVERALL	0.098	0.296		Sw (% Recovery) 3.847
MEAN SELECTED	0.098	0.296		
S.OVERALL	0.009	0.026		
S.SELECTED	0.009	0.026		

TABLE 5.5.5

COBALT

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.1	0.31		ACCEPTABLE PERFORMANCE
3002	0.096	0.297		ACCEPTABLE PERFORMANCE
3003	0.1	0.29		ACCEPTABLE PERFORMANCE
3004	0.1	0.32		ACCEPTABLE PERFORMANCE
3005	0.099	0.298		ACCEPTABLE PERFORMANCE
3006	0.1	0.29		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.11	0.3		ACCEPTABLE PERFORMANCE
3011	0.09	0.29		ACCEPTABLE PERFORMANCE
3013	0.1	0.28		ACCEPTABLE PERFORMANCE
3014				
3015	0.11	0.3		ACCEPTABLE PERFORMANCE
3016	0.104	0.297		ACCEPTABLE PERFORMANCE
3017	0.095	0.28		ACCEPTABLE PERFORMANCE
3018	0.1	0.31		ACCEPTABLE PERFORMANCE
3019	0.1	0.3		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.099	0.279		ACCEPTABLE PERFORMANCE
3024	0.066	0.233	7.3	BIASED LOW, POSSIBLE SLOPE PROBLEM
3025	0.08	0.25	5.2	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.12	0.33	3.5	WARNING: BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3028	0.11	0.33	3.1	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.096	0.31		ACCEPTABLE PERFORMANCE
3030				
3031				
3032	0.09	0.3		ACCEPTABLE PERFORMANCE
3033				
3034				
3035	0.09	0.26	4.0	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3036	0.08	0.28		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.100	0.297		SD3/SD2 1.726
MEDIAN SELECTED	0.100	0.298		
MEAN OVERALL	0.097	0.293		Sw 0.010 ppm
MEAN SELECTED	0.097	0.296		
S.OVERALL	0.011	0.023		
S.SELECTED	0.011	0.019		

TABLE 5.5.6

MOE INTERLABORATORY STUDY MOE89/6 CHROMIUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.1	0.32		ACCEPTABLE PERFORMANCE
3002	0.101	0.294		ACCEPTABLE PERFORMANCE
3003	0.12	0.31		ACCEPTABLE PERFORMANCE
3004	0.1	0.31		ACCEPTABLE PERFORMANCE
3005	0.1	0.301		ACCEPTABLE PERFORMANCE
3006	0.07	0.3		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.096	0.34	2.7	WARNING: SLIGHT IMPRECISION
3011	0.1	0.32		ACCEPTABLE PERFORMANCE
3013	0.1	0.28		ACCEPTABLE PERFORMANCE
3014	0.1	0.27		ACCEPTABLE PERFORMANCE
3015	0.18	0.48	13.3	BIASED HIGH, POSSIBLE SLOPE PROBLEM
3016	0.103	0.308		ACCEPTABLE PERFORMANCE
3017	0.099	0.32		ACCEPTABLE PERFORMANCE
3018	0.11	0.31		ACCEPTABLE PERFORMANCE
3019	0.102	0.296		ACCEPTABLE PERFORMANCE
3020				
3021				
3022	0.071	0.189	7.7	BIASED LOW, PROBABLE SLOPE PROBLEM
3023	0.101	0.283		ACCEPTABLE PERFORMANCE
3024	0.086	0.258		ACCEPTABLE PERFORMANCE
3025	0.08	0.26		ACCEPTABLE PERFORMANCE
3026				
3027	0.11	0.35	3.4	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.11	0.32		ACCEPTABLE PERFORMANCE
3029	0.096	0.3		ACCEPTABLE PERFORMANCE
3030				
3031				
3032	0	0.28	6.9	ONE RESULT ERRATIC
3033				
3034	0.024	0.332	5.6	BOTH RESULTS ERRATIC
3035	0.11	0.29		ACCEPTABLE PERFORMANCE
3036	0.11	0.33		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.100	0.305		SD3/SD2 1.972
MEDIAN SELECTED	0.100	0.305		
MEAN OVERALL	0.095	0.306		Sw 0.015 ppm
MEAN SELECTED	0.099	0.303		
S.OVERALL	0.031	0.047		
S.SELECTED	0.012	0.023		

TABLE 5.5.7

MOE INTERLABORATORY STUDY MOE89/6 COPPER

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.08	0.26	3.3	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3002	0.092	0.255	3.3	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3003	0.08	0.23		ACCEPTABLE PERFORMANCE
3004	0.08	0.23		ACCEPTABLE PERFORMANCE
3005	0.074	0.221		ACCEPTABLE PERFORMANCE
3006	0.09	0.28	5.4	BIASED HIGH, PROBABLE SLOPE PROBLEM
3007				
3008				
3009				
3010	0.11	0.23	3.3	WARNING: ONE RESULT ERRATIC
3011	0.07	0.22		ACCEPTABLE PERFORMANCE
3013	0.075	0.22		ACCEPTABLE PERFORMANCE
3014				
3015	0.072	0.216		ACCEPTABLE PERFORMANCE
3016	0.079	0.229		ACCEPTABLE PERFORMANCE
3017	0.078	0.24		ACCEPTABLE PERFORMANCE
3018	0.08	0.24		ACCEPTABLE PERFORMANCE
3019	0.08	0.24		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.071	0.205		ACCEPTABLE PERFORMANCE
3024	0.079	0.223		ACCEPTABLE PERFORMANCE
3025	0.06	0.19	3.6	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.08	0.25		ACCEPTABLE PERFORMANCE
3028	0.07	0.25	2.4	WARNING: SLIGHT IMPRECISION
3029	0.078	0.24		ACCEPTABLE PERFORMANCE
3030				
3031				
3032	0.09	0.24		ACCEPTABLE PERFORMANCE
3033				
3034				
3035	0.08	0.21		ACCEPTABLE PERFORMANCE
3036	0.06	0.21		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.075	0.225		
MEDIAN OVERALL	0.079	0.230		SD3/SD2 1.661
MEDIAN SELECTED	0.079	0.230		
MEAN OVERALL	0.079	0.232		Sw 0.011 ppm
MEAN SELECTED	0.079	0.230		
S.OVERALL	0.010	0.020		
S.SELECTED	0.010	0.017		

TABLE 5.5.8

MOE INTERLABORATORY STUDY MOEB9/6 IRON

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	1.14	3.25		ACCEPTABLE PERFORMANCE
3002	1.01	3.01		ACCEPTABLE PERFORMANCE
3003	0.97	2.96		ACCEPTABLE PERFORMANCE
3004				
3005	0.996	3		ACCEPTABLE PERFORMANCE
3006	0.91	2.85		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	1.11	3.31		ACCEPTABLE PERFORMANCE
3011	1.1	3.3		ACCEPTABLE PERFORMANCE
3013	0.98	3		ACCEPTABLE PERFORMANCE
3014				
3015	1	2.72		ACCEPTABLE PERFORMANCE
3016	1	3		ACCEPTABLE PERFORMANCE
3017	0.957	2.96		ACCEPTABLE PERFORMANCE
3018	1	3		ACCEPTABLE PERFORMANCE
3019	1.04	3.01		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.98	2.9		ACCEPTABLE PERFORMANCE
3024	0.1	0.254	22.9	BIASED LOW, PROBABLE SLOPE PROBLEM
3025				
3026				
3027	1.11	3.27		ACCEPTABLE PERFORMANCE
3028	1.1	3.32		ACCEPTABLE PERFORMANCE
3029	1.01	3.09		ACCEPTABLE PERFORMANCE
3030				
3031				
3032	0.97	2.9		ACCEPTABLE PERFORMANCE
3033				
3034				
3035	1.16	2.58	3.8	BOTH RESULTS ERRATIC
3036	1.03	2.69		ACCEPTABLE PERFORMANCE
TARGET VALUE	1.000	3.000		
MEDIAN OVERALL	1.000	3.000		SD3/SD2 3.063
MEDIAN SELECTED	1.005	3.000		
MEAN OVERALL	0.984	2.875		Sw (% Recovery) 5.598
MEAN SELECTED	1.029	3.006		
S.OVERALL	0.208	0.619		
S.SELECTED	0.066	0.203		

TABLE 5.5.9

MOE INTERLABORATORY STUDY MOE89/6 — MANGANESE

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.08	0.24		ACCEPTABLE PERFORMANCE
3002	0.082	0.252	3.5	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3003	0.09	0.23		ACCEPTABLE PERFORMANCE
3004				
3005	0.076	0.226		ACCEPTABLE PERFORMANCE
3006	0.08	0.23		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.08	0.22		ACCEPTABLE PERFORMANCE
3011	0.08	0.23		ACCEPTABLE PERFORMANCE
3013	0.08	0.23		ACCEPTABLE PERFORMANCE
3014				
3015	0.1	0.24	3.7	WARNING: BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3016	0.08	0.246		ACCEPTABLE PERFORMANCE
3017				
3018	0.08	0.24		ACCEPTABLE PERFORMANCE
3019	0.09	0.27	6.0	BIASED HIGH, PROBABLE SLOPE PROBLEM
3020				
3021				
3022				
3023	0.077	0.222		ACCEPTABLE PERFORMANCE
3024	0.08	0.21		ACCEPTABLE PERFORMANCE
3025				
3026				
3027	0.09	0.25	3.7	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.09	0.27	6.0	BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.08	0.25	3.2	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3030				
3031				
3032	0.06	0.22		ACCEPTABLE PERFORMANCE
3033				
3034				
3035	0.08	0.24		ACCEPTABLE PERFORMANCE
3036	0.07	0.22		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.075	0.225		
MEDIAN OVERALL	0.080	0.235		
MEDIAN SELECTED	0.080	0.230		
MEAN OVERALL	0.081	0.237		
MEAN SELECTED	0.081	0.233		
S.OVERALL	0.008	0.016		
S.SELECTED	0.008	0.012		

SD3/SD2 1.476

Sw 0.008 ppm

TABLE 5.5.10

MOE INTERLABORATORY STUDY MOE89/6 NICKEL

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sω	
3001	0.1	0.3		ACCEPTABLE PERFORMANCE
3002	0.104	0.286		ACCEPTABLE PERFORMANCE
3003	0.13	0.34	5.5	BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3004	0.1	0.31		ACCEPTABLE PERFORMANCE
3005	0.102	0.306		ACCEPTABLE PERFORMANCE
3006	0.1	0.3		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.12	0.32	3.1	WARNING: BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3011	0.11	0.32		ACCEPTABLE PERFORMANCE
3013	0.1	0.29		ACCEPTABLE PERFORMANCE
3014				
3015	0.1	0.29		ACCEPTABLE PERFORMANCE
3016	0.11	0.32		ACCEPTABLE PERFORMANCE
3017	0.098	0.3		ACCEPTABLE PERFORMANCE
3018	0.08	0.38	9.1	BOTH RESULTS ERRATIC
3019	0.1	0.3		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.098	0.28		ACCEPTABLE PERFORMANCE
3024	0.09	0.321	2.6	WARNING: SLIGHT IMPRECISION
3025	0.08	0.25	5.9	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.13	0.37	8.4	BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.1	0.34	4.4	WARNING: ONE RESULT ERRATIC
3029	0.12	0.34	4.9	BIASED HIGH, PROBABLE SLOPE PROBLEM
3030				
3031				
3032	0.1	0.31		ACCEPTABLE PERFORMANCE
3033				
3034				
3035	0.14	0.31	4.5	ONE RESULT ERRATIC
3036	0.09	0.31		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.100	0.310		SD3/SD2 0.952
MEDIAN SELECTED	0.100	0.306		
MEAN OVERALL	0.104	0.313		Sω 0.009 ppm
MEAN SELECTED	0.103	0.304		
S.OVERALL	0.015	0.028		
S.SELECTED	0.013	0.012		

TABLE 5.5.11

MOE INTERLABORATORY STUDY MOE89/6 LEAD

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.48	1.51		ACCEPTABLE PERFORMANCE
3002	0.544	1.52		ACCEPTABLE PERFORMANCE
3003	0.56	1.48		ACCEPTABLE PERFORMANCE
3004	1	1.7	12.8	BIASED HIGH OR ERRATIC
3005	0.515	1.6		ACCEPTABLE PERFORMANCE
3006	0.45	1.52		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.48	1.47		ACCEPTABLE PERFORMANCE
3011	0.53	1.54		ACCEPTABLE PERFORMANCE
3013	0.47	1.38		ACCEPTABLE PERFORMANCE
3014				
3015	0.58	1.58		ACCEPTABLE PERFORMANCE
3016	0.529	1.58		ACCEPTABLE PERFORMANCE
3017	0.475	1.45		ACCEPTABLE PERFORMANCE
3018	0.5	1.6		ACCEPTABLE PERFORMANCE
3019	0.5	1.51		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.51	1.49		ACCEPTABLE PERFORMANCE
3024	0.053	1.48	10.6	ONE RESULT ERRATIC
3025	0.41	1.27	5.9	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.59	1.79	7.2	BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.56	1.75	6.1	BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.58	1.68	4.7	BIASED HIGH, PROBABLE SLOPE PROBLEM
3030				
3031				
3032				
3033				
3034				
3035	0.44	1.53		ACCEPTABLE PERFORMANCE
3036	0.48	1.56		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.500	1.500		
MEDIAN OVERALL	0.505	1.525		SD3/SD2 1.151
MEDIAN SELECTED	0.505	1.520		
MEAN OVERALL	0.511	1.545		Sw 0.042 ppm
MEAN SELECTED	0.509	1.518		
S.OVERALL	0.150	0.114		
S.SELECTED	0.049	0.056		

TABLE 5.5.12

MOE INTERLABORATORY STUDY MOE89/6 VANADIUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.1	0.32		ACCEPTABLE PERFORMANCE
3002	0.107	0.294		ACCEPTABLE PERFORMANCE
3003	0.102	0.289		ACCEPTABLE PERFORMANCE
3004	0.09	0.3		ACCEPTABLE PERFORMANCE
3005	0.11	0.33	3.8	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3006	0.1	0.29		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010				
3011	0.1	0.31		ACCEPTABLE PERFORMANCE
3013	0.1	0.3		ACCEPTABLE PERFORMANCE
3014				
3015				
3016				
3017	0.093	0.294		ACCEPTABLE PERFORMANCE
3018	0.1	0.29		ACCEPTABLE PERFORMANCE
3019	0.1	0.3		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.1	0.284		ACCEPTABLE PERFORMANCE
3024				
3025	0.08	0.25	6.5	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.1	0.31		ACCEPTABLE PERFORMANCE
3028	0.11	0.32		ACCEPTABLE PERFORMANCE
3029	0.11	0.3		ACCEPTABLE PERFORMANCE
3030				
3031				
3032				
3033				
3034				
3035	0.1	0.22	9.7	ONE RESULT ERRATIC
3036	0.09	0.28		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.100	0.297		SD3/SD2 1.821
MEDIAN SELECTED	0.100	0.300		
MEAN OVERALL	0.100	0.293		Sw 0.008 ppm
MEAN SELECTED	0.100	0.301		
S.OVERALL	0.007	0.025		
S.SELECTED	0.007	0.014		

TABLE 5.5.13

MOE INTERLABORATORY STUDY MOE89/6 ZINC

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.13	0.4		ACCEPTABLE PERFORMANCE
3002	0.129	0.402		ACCEPTABLE PERFORMANCE
3003	0.13	0.4		ACCEPTABLE PERFORMANCE
3004	0.13	0.39		ACCEPTABLE PERFORMANCE
3005	0.127	0.358		ACCEPTABLE PERFORMANCE
3006	0.1	0.33		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010	0.13	0.36		ACCEPTABLE PERFORMANCE
3011	0.09	0.36		ACCEPTABLE PERFORMANCE
3013	0.13	0.38		ACCEPTABLE PERFORMANCE
3014	0.11	0.325	3.1	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3015	0.12	0.37		ACCEPTABLE PERFORMANCE
3016	0.128	0.379		ACCEPTABLE PERFORMANCE
3017	0.124	0.5	7.3	ONE RESULT ERRATIC
3018	0.12	0.38		ACCEPTABLE PERFORMANCE
3019	0.107	0.308	4.1	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3020				
3021				
3022	0.101	0.334		ACCEPTABLE PERFORMANCE
3023	0.122	0.34		ACCEPTABLE PERFORMANCE
3024	0.145	0.402		ACCEPTABLE PERFORMANCE
3025	0.1	0.3	4.6	BIASED LOW, PROBABLE SLOPE PROBLEM
3026				
3027	0.14	0.43	3.3	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3028	0.14	0.43	3.3	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3029	0.14	0.4		ACCEPTABLE PERFORMANCE
3030				
3031				
3032	0.09	0.35		ACCEPTABLE PERFORMANCE
3033				
3034	0.168	0.408	3.2	WARNING: BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3035	0.14	0.37		ACCEPTABLE PERFORMANCE
3036	0.12	0.36		ACCEPTABLE PERFORMANCE
TARGET VALUE	0.125	0.375		
MEDIAN OVERALL	0.128	0.375		SD3/SD2 1.939
MEDIAN SELECTED	0.128	0.370		
MEAN OVERALL	0.124	0.376		Sw 0.017 ppm
MEAN SELECTED	0.124	0.371		
S.OVERALL	0.018	0.042		
S.SELECTED	0.018	0.034		

TABLE 5.5.14

MOE INTERLABORATORY STUDY MOE89/6 ARSENIC

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.12	0.31		ACCEPTABLE PERFORMANCE
3002	0.1	0.312		ACCEPTABLE PERFORMANCE
3003	0.101	0.307		ACCEPTABLE PERFORMANCE
3004	0.087	0.27		ACCEPTABLE PERFORMANCE
3005	0.102	0.32		ACCEPTABLE PERFORMANCE
3006	0.107	0.368	3.6	WARNING: ONE RESULT ERRATIC
3007				
3008				
3009				
3010	0.06	0.244	6.6	BIASED LOW, PROBABLE INTERCEPT PROBLEM
3011	0.113	0.358	3.5	WARNING: BIASED HIGH, PROBABLE SLOPE PROBLEM
3013	0.099	0.26		ACCEPTABLE PERFORMANCE
3014				
3015				
3016				
3017				
3018	0.08	0.24	4.2	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3019	0.14	0.44	9.2	BIASED HIGH, PROBABLE SLOPE PROBLEM
3020				
3021				
3022				
3023	0.11	0.34		ACCEPTABLE PERFORMANCE
3024				
3025				
3026				
3027	0.095	0.3		ACCEPTABLE PERFORMANCE
3028	0.103	0.316		ACCEPTABLE PERFORMANCE
3029	0.1	0.31		ACCEPTABLE PERFORMANCE
3030				
3031				
3032				
3033				
3034				
3035	0.092	0.3		ACCEPTABLE PERFORMANCE
3036				
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.101	0.310		SD3/SD2 2.139
MEDIAN SELECTED	0.101	0.310		
MEAN OVERALL	0.101	0.312		Sw (% Recovery) 6.673
MEAN SELECTED	0.101	0.304		
S.OVERALL	0.017	0.048		
S.SELECTED	0.017	0.036		

TABLE 5.5.15

MOE INTERLABORATORY STUDY MOE89/6 SELENIUM

LAB-CODE	RESULT MET 2 ppm	RESULT MET 3 ppm	TOTAL ERROR Sw	
3001	0.12	0.32	3.7	WARNING: BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3002	0.103	0.298		ACCEPTABLE PERFORMANCE
3003	0.1	0.32		ACCEPTABLE PERFORMANCE
3004				
3005	0.112	0.3		ACCEPTABLE PERFORMANCE
3006	0.116	0.311		ACCEPTABLE PERFORMANCE
3007				
3008				
3009				
3010				
3011				
3013	0.101	0.24	7.8	ONE RESULT ERRATIC
3014				
3015				
3016				
3017				
3018	0.07	0.21	12.4	BIASED LOW, PROBABLE SLOPE PROBLEM
3019	0.102	0.3		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023	0.092	0.3		ACCEPTABLE PERFORMANCE
3024				
3025				
3026				
3027	0.1	0.33	3.9	WARNING: ONE RESULT ERRATIC
3028	0.107	0.31		ACCEPTABLE PERFORMANCE
3029	0.09	0.31		ACCEPTABLE PERFORMANCE
3030				
3031				
3032				
3033				
3034				
3035	0.099	0.289		ACCEPTABLE PERFORMANCE
3036				
TARGET VALUE	0.100	0.300		
MEDIAN OVERALL	0.101	0.300		SD3/SD2 1.113
MEDIAN SELECTED	0.102	0.305		
MEAN OVERALL	0.101	0.295		Sw 0.008 ppm
MEAN SELECTED	0.104	0.306		
S.OVERALL	0.012	0.032		
S.SELECTED	0.009	0.010		

TABLE 5.5.16

MOE INTERLABORATORY STUDY MOE89/6 TOT. PHOS.

LAB-CODE	RESULT NUT 2 ppm	RESULT NUT 3 ppm	TOTAL ERROR Sw	
3001	0.14	0.54		ACCEPTABLE PERFORMANCE
3002	0.06	0.41	5.3	BIASED LOW, POSSIBLE INTERCEPT PROBLEM
3003	0.128	0.499		ACCEPTABLE PERFORMANCE
3004				
3005	0.13	0.86	11.3	ONE RESULT ERRATIC
3006	0.04	0.22	11.8	BIASED LOW, PROBABLE SLOPE PROBLEM
3007	0.141	0.56		ACCEPTABLE PERFORMANCE
3008	0.12	0.54		ACCEPTABLE PERFORMANCE
3009	0.1	0.57		ACCEPTABLE PERFORMANCE
3010	0.14	0.52		ACCEPTABLE PERFORMANCE
3011	0.11	0.52		ACCEPTABLE PERFORMANCE
3013	0.14	0.5		ACCEPTABLE PERFORMANCE
3014	0.06	0.24	10.9	BIASED LOW, PROBABLE SLOPE PROBLEM
3015	1.99	1	67.4	BIASED HIGH OR ERRATIC
3016	0.138	0.55		ACCEPTABLE PERFORMANCE
3017				
3018				
3019	0.116	0.528		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023				
3024	0.15	0.54		ACCEPTABLE PERFORMANCE
3025				
3026	0.11	0.56		ACCEPTABLE PERFORMANCE
3027				
3028	0.12	0.42	4.3	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3029	0.2	0.5	2.7	WARNING: SLIGHT IMPRECISION
3030	0.11	0.56		ACCEPTABLE PERFORMANCE
3031	0.2	0.7	6.1	BIASED HIGH, PROBABLE SLOPE PROBLEM
3032	0.11	0.48		ACCEPTABLE PERFORMANCE
3033	0.053	0.193	12.6	BIASED LOW, PROBABLE SLOPE PROBLEM
3034	0.11	0.54		ACCEPTABLE PERFORMANCE
3035				
3036	0.0788	0.217	11.6	BIASED LOW, PROBABLE SLOPE PROBLEM
TARGET VALUE	0.135	0.540		
MEDIAN OVERALL	0.120	0.528		SD3/SD2 0.755
MEDIAN SELECTED	0.120	0.540		
MEAN OVERALL	0.192	0.511		Sw 0.028 ppm
MEAN SELECTED	0.123	0.532		
S.OVERALL	0.454	0.186		
S.SELECTED	0.034	0.026		

TABLE 5.5.17

MOE INTERLABORATORY STUDY MOE89/6 TKN

LAB-CODE	RESULT NUT 2 ppm	RESULT NUT 3 ppm	TOTAL ERROR Sw	
3001	2.4	9.6		ACCEPTABLE PERFORMANCE
3002	2.01	7.56	6.4	BIASED LOW, PROBABLE SLOPE PROBLEM
3003	2.14	8.44	3.7	WARNING: BIASED LOW, PROBABLE SLOPE PROBLEM
3004	4.6	8.1	8.2	BOTH RESULTS ERRATIC
3005	2.4	9.5		ACCEPTABLE PERFORMANCE
3006	3.1	9.1	2.7	WARNING: SLIGHT IMPRECISION
3007	2.59	9.99		ACCEPTABLE PERFORMANCE
3008				
3009	2.17	9.82		ACCEPTABLE PERFORMANCE
3010	0.82	5.67	13.1	BIASED LOW, POSSIBLE SLOPE PROBLEM
3011	2.6	9.5		ACCEPTABLE PERFORMANCE
3013	2.6	9.6		ACCEPTABLE PERFORMANCE
3014				
3015				
3016	2.2	9.2		ACCEPTABLE PERFORMANCE
3017				
3018		·1.45		
3019	2.48	9.6		ACCEPTABLE PERFORMANCE
3020				
3021				
3022				
3023				
3024	2.2	10.26	2.1	WARNING: SLIGHT IMPRECISION
3025				
3026				
3027	6.03	6	15.8	BOTH RESULTS ERRATIC
3028	2.55	9.83		ACCEPTABLE PERFORMANCE
3029	1.6	4.4	16.2	BIASED LOW, POSSIBLE SLOPE PROBLEM
3030	2.38	9.4		ACCEPTABLE PERFORMANCE
3031				
3032	2.68	9.6		ACCEPTABLE PERFORMANCE
3033				
3034				
3035				
3036				

TARGET VALUE	2.400	9.600		
MEDIAN OVERALL	2.400	9.450	SD3/SD2	0.915
MEDIAN SELECTED	2.400	9.600		
MEAN OVERALL	2.608	8.331	Sw	0.324 ppm
MEAN SELECTED	2.381	9.615		
S.OVERALL	1.061	2.220		
S.SELECTED	0.326	0.290		

TABLE 5.5.18

PHENOL

LAB-CODE	RESULT PHN 2 ppm	RESULT PHN-3 ppm	TOTAL ERROR Sw	
3001	0.0099	0.039		ACCEPTABLE PERFORMANCE
3002	0.0099	0.0401		ACCEPTABLE PERFORMANCE
3003	0.009	0.04		ACCEPTABLE PERFORMANCE
3004	0.01	0.064	27.8	ONE RESULT ERRATIC
3005	0.011	0.038	2.6	WARNING: SLIGHT IMPRECISION
3006	0.006	0.02	23.6	BIASED LOW, POSSIBLE SLOPE PROBLEM
3007	0.01	0.0395		ACCEPTABLE PERFORMANCE
3008	0.0088	0.04		ACCEPTABLE PERFORMANCE
3009	0.007	0.039	3.7	WARNING: ONE RESULT ERRATIC
3010	0.003	0.012	33.4	BIASED LOW, PROBABLE SLOPE PROBLEM
3011	0.005	0.035	8.2	BIASED LOW, PROBABLE INTERCEPT PROBLEM
3013	0.01	0.04		ACCEPTABLE PERFORMANCE
3014	0.006	0.036	6.6	BIASED LOW, PROBABLE INTERCEPT PROBLEM
3015	0	0.28		ERRATIC
3016	0.0082	0.037	4.1	WARNING: BIASED LOW, PROBABLE INTERCEPT PROBLEM
3017				
3018	0.002	0.06	25.0	BOTH RESULTS ERRATIC
3019	0.01	0.04		ACCEPTABLE PERFORMANCE
3020				
3021	0.007	0.031	11.0	BIASED LOW, PROBABLE SLOPE PROBLEM
3022	0.0068	0.0356	6.3	BIASED LOW, PROBABLE INTERCEPT PROBLEM
3023				
3024	0.002	0.035	10.9	BIASED LOW OR ERRATIC
3025	0.01	0.04		ACCEPTABLE PERFORMANCE
3026	0.008	0.037	4.2	WARNING: BIASED LOW, PROBABLE INTERCEPT PROBLEM
3027	0.0103	0.039		ACCEPTABLE PERFORMANCE
3028	0.011	0.04		ACCEPTABLE PERFORMANCE
3029				
3030				
3031	0.002	0.026	18.7	BIASED LOW
3032	0.0122	0.0433	4.6	BIASED HIGH, PROBABLE INTERCEPT PROBLEM
3033	0.029	0.057	29.5	BIASED HIGH, POSSIBLE INTERCEPT PROBLEM
3034	0.0105	0.0494	10.9	ONE RESULT ERRATIC
3035	0.006	0.038	5.2	BIASED LOW, POSSIBLE INTERCEPT PROBLEM
3036	0.0505	0.1163	100.1	BIASED HIGH
TARGET VALUE	0.010	0.040		
MEDIAN OVERALL	0.009	0.039		SD3/SD2 1.069
MEDIAN SELECTED	0.010	0.039		
MEAN OVERALL	0.010	0.050		Sw 0.001 ppm
MEAN SELECTED	0.009	0.039		
S.OVERALL	0.009	0.046		
S.SELECTED	0.002	0.002		